JOURNAL OF MATERIALS SCIENCE 8 (1973) 705–753

Rapid quenching from the melt: An annotated bibliography 1958-72

H. JONES
Department of Metallurgy, University of Sheffield
C. SURYANARAYANA
Department of Metallurgical Engineering, Banaras Hindu University, Varanasi-5, India

A comprehensive classified list of annotated references on rapid cooling from the liquid to the solid state is presented, covering the period 1958 to 1971 and embracing the range of cooling rates greater than $\sim 10^5$ K sec^{-1}. An index of authors and of alloys studied is appended, supplemented with a list of references for 1972, as known at time of going to press.

1. Introduction

A new field of research activity has grown from the reports by Duwez *et al* in 1960 of solid solubility extension [105, 106] and new metastable crystalline [185] or amorphous [239] solid phases in some simple binary eutectic alloy systems. Duwez achieved these effects by introducing two new techniques for impelling a liquid alloy sample (mass $\sim$50 mg) at a single moving or stationary substrate to be spread into a thin layer which then solidified rapidly. Russian workers almost simultaneously introduced a device [31, 84, 151] for spreading such a liquid alloy sample between *two* mutually approaching substrates, obtaining evidence for changes of solidification mode and for solid solubility extension. Such effects have since been confirmed for numerous alloy systems and many modifications and improvements in the technique of cooling the melt have been developed. The question of suitable terminology to describe the technique has been debated (*J. Metals* **17** (1965) 1167, 1180, 1284; **18** (1966) 148, 286, 1090, 1156). The term "splat cooling"* [49] or, "splat quenching" has gained wide currency in spite of recent attempts [e.g. 2, 30, 218], to establish the self-explicit term "liquisol quenching" (due to Srivastava, *J. Metals* **18** (1966) 1156). The subject has been reviewed repeatedly (Section 3.1), including an alphabetical classification, in terms of alloy system, of work up to December 1968 [15], and a chronological, but incomplete, list of papers published between 1960 and 1970 [11]. The present bibliography, as well as embracing and up-dating these earlier publications, classifies individual references into review articles (Section 3.1; entries 1-20), quenching methods (Section 3.2; entries 21-39), process mechanisms (Section 3.3; entries 40-50), as-quenched microstructure (Section 3.4.A; entries 51-94), terminal solid solubility extension (Section 3.4.B; entries 95-176), metastable crystalline intermediate phases (Section 3.5.A; entries 177-222), amorphous solid phases (Section 3.5.B; entries 223-258), annealing behaviour (Section 3.6; entries 259-299), electrical and magnetic properties (Section 3.7.A; entries 300-345), mechanical properties (Section 3.7.B; entries 346-372) and practical applications (Section 3.7.C; entries 373-402). These divisions emerge naturally from the development of the subject and are basically those used by the authors in their recent comprehensive reviews [2, and H. Jones, accepted for publication in *Rep. Progr. Phys.*].

The criterion determining inclusion in the present compilation is some indication that a cooling rate approaching or exceeding 10^5 K sec^{-1} from the liquid to the solid state had been achieved in connection with experimental results, reported or discussed. This appears to be the lower limit at which non-equilibrium effects of the kind reported by Duwez *et al* in 1960 become widespread. It is also the upper limit of normal fluid quenching techniques [9], including liquid

*This term was also used earlier in *Chem. Eng. News* **38** (25) (1960) 49, in connection with Duwez' earliest work atomization,* and of normal chill casting techniques. Unpublished reports and theses are not included except in some cases where a published abstract has been located. Quenching technique (QT), quenched thickness achieved (z) and authors' estimate of cooling rate (dT/dt) are reported where specified, together with the alloys studied. Quenching techniques are summarized in Tables Ia, b and c. Appendices 1 and 2 are indexes, for 1958-72, of authors and of alloy systems studied, respectively. Appendix 3 lists references for 1972 known to the present authors at the time of going to press; these entries are included in the author and subject indexes.

2. Abbreviations

at. % = atomic per cent
AS = amorphous solid or noncrystalline
DTA = differential thermal analysis
MCS = metastable crystalline solid
QT = quenching technique
T = temperature
dT/dt = cooling rate
TEM = transmission electron microscopy
TSSE = terminal solid solubility extension
wt % = weight per cent
XRD = X-ray diffraction
z = thickness of as-quenched specimen.

Italicizing one component in a specified alloy system indicates that component forms the base of the alloys specified (i.e. comprises $\geqslant$ 50 at. %).

Chemical symbols are used throughout for brevity to designate components of alloy systems and unalloyed elements, and designations of crystal structure are abbreviated in the normal way (fcc, bcc, cph) throughout.

3. Bibliography for 1958-71

3.1. Review articles†

[See also 26, 70, 85-6, 127-8, 131-2, 155, 226, 257-8, 354, 398, A14, A20, A49]

1. T. R. ANANTHARAMAN and P. RAMACHANDRARAO, "On the Duwez Technique of Liquid Quenching", *Eastern Metals Review* **19** (1966) 141-5.
   Review of early work done in USA (up to 1965), covering TSSE, new MCS phases and AS phases (28 references).
2. T. R. ANANTHARAMAN and C. SURYANARAYANA, "A Decade of Quenching from the Melt", *J. Mater. Sci.* **6** (1971) 1111-35.
   A balanced review of work published up to 1970 including tabulations with references of alloy compositions for which TSSE, new MCS phases and AS phases had been observed and for which mechanical, superconducting and magnetic properties had been studied (196 references).
3. P. DUWEZ, "Metastable Phases Obtained by Rapid Solidification" in *Energetics in Metallurgical Phenomena*, Vol. 1, Ed. W. M. Mueller (Gordon and Breach, New York, 1965) pp. 193-203.
   Review of earliest work in USA (1960-2) with 11 references.
4. P. DUWEZ, "Metastable Solid Solutions" in *Alloying Behaviour and Effects in Concentrated Solid Solutions*, Ed. T. B. Massalski (Gordon and Breach, New York, 1965) pp. 420-32.
   Review of work done in USA up to 1964, placing emphasis on TSSE and AS phases (22 references).
5. P. DUWEZ, "Metastable Phases Obtained by Rapid Quenching from the Liquid State" in *Progress in Solid State Chemistry*, Vol. 3, Ed. H. Reiss (Pergamon Press, New York, 1966) pp. 377-406.
   Detailed review of work done in USA up to 1965 (50 references).
6. P. DUWEZ, "Metastable Phases" in *Intermetallic Compounds*, Ed. J. H. Westbrook (Wiley, New York, 1967) pp. 340-8.
   Review of work done in USA up to 1963, including a section on phases obtained at high pressures (38 references, including an addendum of 12 for 1964-6).
7. P. DUWEZ, "Metastable Phases" in *Phase Stability in Metals and Alloys*, Ed. P. S. Rudman, J. Stringer, and R. I. Jaffee (McGraw-Hill, New York, 1967) pp. 523-38.
   Review of selected work done up to 1966, with the emphasis on AS phases (21 references).
8. P. DUWEZ, "Structure and Properties of Alloys Rapidly Quenched from the Liquid State", *Trans. Amer. Soc. Metals* **60** (1967) 607-33.
   Detailed review of work done in USA up to 1967, emphasizing AS phases and including early results on their electronic properties and annealing behaviour (67 references).
9. P. DUWEZ, "Rapid Quenching Techniques" in *Techniques of Metals Research*, Vol. 1, Pt. 1, Ed.

*Very small droplets (~ 300 Å diameter) made by explosive vaporization of Au wires (F. G. Karioris, J. J. Woyci, and R. R. Buckrey, *Adv. X-ray Analysis* **10** (1967) 250-64), however, were calculated to have solidified by radiation cooling at ~ 10^6 K sec^{-1}.

†In addition to these, the proceedings of an Internation Conference mainly concerned with the effects of rapid cooling of molten alloys have been published in *Fizika* **2** Suppl. 2 (1970). Reports on this conference appeared in *Nature* **228** (1970) 212-3 in *Mater. Sci. Eng.* **7** (1971) 119-21 and (in German) in *Metall* **25** (1971) 151-3.

R. F. Bunshah (Interscience, New York, 1968) pp. 347-58.

Review of techniques available up to 1966 including brief treatment of solid state quenching and use of fluids as quenching media (41 references).

10. P. DUWEZ, "Metals, glassy" in *Yearbook of Science and Technology* (McGraw-Hill, New York, 1969) pp. 206-9.

Brief summary indicating gun and piston-and-anvil techniques and electronic behaviour of Pd-Si and Fe-P-C amorphous solids.

11. P. DUWEZ, "Liquid Quenched Metallic Metastable Alloys", *Fizika* **2** Suppl. 2 (1970) pp. 1.1-1.15.

Brief review of occurrence and properties of AS metallic alloys with a bibliography (from CALT-822-17, December 1970) of 164 references on alloys quenched from the liquid state, covering 1960-70.

12. P. FURRER and H. WARLIMONT, "Microstructure and Properties of Aluminium Alloys after Rapid Solidification. I. Rapid Quenching Techniques, Structural and Microstructural Features", *Z. Metallk.* **62** (1971) 12-20 (in German).

Part I of comprehensive review of work on Al alloys up to 1970, including morphological changes and new MCS phases (120 references). See also [13].

13. P. FURRER and H. WARLIMONT, "Microstructure and Properties of Aluminium Alloys after Rapid Solidification. II. Extension of Solid Solubility Effect of Thermal Treatment, Mechanical Properties" *Z. Metallk.* **62** (1971) 100-112 (in German).

Part II of comprehensive review of work on Al alloys up to 1970 including TSSE and the effect of annealing mainly in binary and some ternary alloys with transition metals. Consideration of hardness and tensile mechanical properties concludes with assessment of prospects for commercial exploitation (134 references). See also [12].

14. B. C. GIESSEN, "Rapidly Quenched (Splat-Cooled) Alloys" in *Strengthening Mechanisms: Metals and Ceramics*, Proc. 12th Sagamore Army Materials Research Conference, 1965, Ed. J. J. Burke, N. L. Reed, and V. Weiss (Syracuse University Press, Syracuse, New York, 1966) pp. 273-90.

Review emphasizing early work at MIT, including studies of splat formation, the relation between quenched phase plots and equilibriun diagrams and the effect of annealing on an extended terminal solid solution (Al-11 at. % Si). (33 references.)

15. B. C. GIESSEN, "Constitution of Non-Equilibrium Alloys after Rapid Quenching from the Melt" in *Developments in the Structural Chemistry of Alloy Phases*, Ed. B. C. Giessen (Plenum Press, New York, 1969) pp. 227-81.

Classification of work available up to December 1968 in alphabetical order of alloy system, including 133 binary and 28 ternary systems (150 references).

16. B. C. GIESSEN, "Crystal Chemistry of Stable and Metastable (Rapidly Quenched) B-Metal Alloy Phases" in *Advances in X-ray Analysis*, Vol. 12, Ed. C. S. Barrett, J. B. Newkirk, and G. R. Mallett (Plenum Press, New York, 1969) pp. 23-48. Discussion pp. 48-9.

Collection and correlation of equilibrium and non-equilibrium, terminal and intermediate, crystalline phases formed in alloys between elements within the block B2 to B5 of the periodic table, with particular attention to the Al-Ga and In-Bi systems (41 references, to 1968).

17. B. C. GIESSEN and R. H. WILLENS, "Rapidly Quenched (Splat-Cooled) Metastable Alloy Phases; Their Phase-Diagram Representation, Preparation Methods, Occurrence and Properties", in *Phase Diagrams: Materials Science and Technology*, Vol. 3, Ed. A. M. Alper (Academic Press, New York, 1970) pp. 103-41.

Reviewed main principles underlying phenomenology of splat-cooling emerging from published work up to 1969, including properties of splat-cooled alloys (87 references).

18. R. HASEGAWA, "Amorphous Ferromagnets", *Solid State Physics (Tokyo)* **5** No. 2 (1970) 3-11 (in Japanese).

Reviewed ferromagnetic properties of amorphous solids formed by splat-cooling, vapour quenching and other deposition quenching techniques (44 references, to 1969).

19. J. MONDON, "New Metastable Phases of Binary Metallic Alloys Obtained by Ultrarapid Freezing of Liquid or by Condensation of Vapour", *Métaux Corrosion Industries* **38** (1963) 427-37 (in French).

Reviewed work published up to 1963 including some on alloy vapour deposition, and early work on properties (26 references).

20. P. RAMACHANDRARAO and T. R. ANANTHARAMAN, "Rapid Cooling of Liquid Metals and Alloys", Proc. Symposium on Materials Science Research in India, 1970, Vol. II (Bhabha Atomic Research Centre, Bombay, 1971) pp. 329-41. Discussion pp. 342-5. From *Metals Abs.* **4** No. 7 (1971) 72-0158, **5** No. 12 (1972) 22-0828.

Reviewed techniques of splat cooling together with TSSE and formation of MCS and AS phases (47 references, up to 1969).

3.2. Quenching methods

[See also Table Ia-c and refs. 9, 14, 42, 45, 46, 48, 49, 51, 54, 55, 61, 63, 66, 68, 82, 86, 104, 105, 110, 138, 149, 151, 157, 164, 205, 250, 293, 324, 348, 352-353, 355, 357-361, 375, 376, 378, 385, 395-6, A5, A11, A12, A27, A30, A34, A35, A39, A61a, A64].

21. E. BABIĆ, E. GIRT, R. KRSNIK, and B. LEONTIĆ, "Production of Large Samples of Ultra-Rapidly Quenched Alloys of Al by means of a Rotating Mill Device", *J. Phys. E: Sci. Instrum.* **3** (1970) 1014-15.

Described a twin-roll device for generating from liquid long uniform strips of quenched solid e.g. of *Al*-Fe alloys. (QT: 9b.) See also [22].

22. E. BABIĆ, E. GIRT, R. KRSNIK, B. LEONTIĆ, and I. ZORIĆ, "Production of Large Rapidly Quenched Alloy Samples", *Fizika* **2** Suppl. 2 (1970) 2.1-2.3.

Development of [21] with Cr-plated steel rather than brass twin rollers, again with *Al*-Fe alloy specimens. (QT: 9b.) Discussion p. 2.4. See also [21].

23. J. N. BAKER, C. E. MIGHTON, and W. R. BITLER, "Modified Rapid Quenching Apparatus", *Rev. Sci. Instrum.* **40** (1969) 1065-6.

Described piston-and-anvil apparatus, hydraulically driven and employing levitation melting, tested to show TSSE of Ge in Ag. (QT: 6f.)

24. A. R. BOOTH and J. A. CHARLES, "Levitation Melting Apparatus for Phase Equilibrium Studies", *Nature* **212** (1966) 750-1.

Described piston-and-anvil apparatus, electromagnetically-driven and employing levitation melting. (QT: 6d.)

25. H. S. CHEN and C. E. MILLER, "A Rapid Quenching Technique for the Preparation of Thin Uniform Films of Amorphous Solids", *Rev. Sci. Instrum.* **41** (1970) 1237-8.

Described twin-roll device employing levitation melting to produce uniform ribbons or ovals. Tested to produce amorphous solid *Pd*-Si and Te base etc alloys. (QT: 9a.)

26. P. DUWEZ and R. H. WILLENS, "Rapid Quenching of Liquid Alloys", *Trans. Met. Soc. AIME* **227** (1963) 362-5.

Described rotating substrate (QT: 3a) and ski-jump (QT: 1a) shock tube devices, with brief review of early results on metallic alloys.

27. F. GALASSO and R. VASLET, "Electron Beam Apparatus for Forming Rapidly Cooled Materials", *Rev. Sci. Instrum.* **37** (1966) 525 only.

Described use of electron beam welding equipment to melt alloy samples subsequently swept against an anvil by an electromagnetically-driven piston. Tested to produce AS *Pd*-Si and strained β-boron. (QT: 6c.)

28. C. P. HINESLEY and J. G. MORRIS, "A Method for Producing Rapidly Cooled Liquid-Quenched Metal Samples Suitable for Tensile Testing", *Metall. Trans.* **1** (1970) 1476-8.

Described injection-mould device for producing cylindrical specimens 0.5 mm diameter, tested to extend solid solubility of Mn in Al to 2.41 wt %. (QT: 10.)

29. H. JONES and M. H. BURDEN, "A Rotary Atomization Technique for Bulk Splat Cooling", *J. Phys. E: Sci. Instrum.* **4** (1971) 671-4.

Described apparatus for semi-continuous splat-cooling by substrate quenching of liquid alloy expelled from the lip of a continuously-fed rotating crucible. Tested with Al-4 at. % Fe alloy. (QT: 4c.)

30. E. LAINE, E. HEIKKILA, and I. LÄHTEENMÄKI, "A Simple Apparatus for Liquisol Quenching", *Rev. Sci. Instrum.* **42** (1971) 1724-5.

Described piston-and-anvil device of quenching alloy melted in a graphite crucible. (QT: 6i.)

31. I. S. MIROSHNICHENKO and I. V. SALLI, "A Device for the Crystallization of Alloys at a High Cooling Rate", *Ind. Lab.* **25** (1959) 1463-4 (From *Zavodskaya Lab.* **25** (1959) 1398-9).

Described piston-and-anvil device for quenching melt catapulted from a small furnace. Tested on *Ni*-C and *Al*-Mn to extend solid solubility and on *Fe*-C. (QT: 6a.) See also [84, 151].

32. P. PIETROKOWSKY, "Novel Mechanical Device for Producing Rapidly Cooled Metals and Alloys of Uniform Thickness", *Rev. Sci. Instrum.* **34** (1963) 445-6.

Described piston-and-anvil device for quenching alloy melted in a graphite crucible. Tested with eutectic alloys to produce an extended solid solution (for Ag-Cu) and a metastable cph phase (for *Ag*-Ge) (QT: 6b.)

33. R. POND and R. MADDIN, "A Method of Producing Rapidly Solidified Filamentary Castings", *Trans. Met. Soc. AIME* **245** (1969) 2475-6.

Described rotating-cup device for generating solid filaments from melt ejected from a travelling source. Tested to show continuous extended solid solubility in Cu-Ag alloys. (QT: 3f.)

34. P. RAMACHANDRARAO, D. BANERJEE, and T. R. ANANTHARAMAN, "An Improved Piston-and-Anvil Technique for Quenching Liquid Metals", *Metall. Trans* **1** (1970) 2655-7.

Described piston-and-anvil device for quenching melt expelled from a shock tube. Tested to obtain TSSE in two alloys (of Cu-Ag and Au-Ge). (QT: 6h.)

35. R. ROBERGE and H. HERMAN, "A Novel Method for Rapid Quenching of Liquid Alloys: The Torsion Catapult", *Mat. Sci. Eng.* **3** (1968) 62-3.

Described torsion catapult device for impelling melt from a crucible. Tested to obtain TSSE in unspecified Al alloys. (QT: 2b.)

36. I. V. SALLI and L. P. LIMINA, "Device for the Crystallization of Alloys at High Cooling Rates", *Ind. Lab.* **31** (1965) 141-2 (From *Zavodskaya Lab.* **31** (1965) 120-1).

Described two devices involving spreading the melt,

in the first device between two rotating discs, one bent against a roller (QT: 8), and in the second inside a rotating cylinder (QT: 3b). Tested to show TSSE in *Al*-Mn and Pb-Cu alloys.

37. G. THURSFIELD and H. JONES, "A Gas Atomization/Spray Quenching Technique for Bulk Splat Cooling", *J. Phys. E: Sci. Instrum.* **4** (1971) 675-6.

    Described apparatus for Ar-blast spraying of melt against scraped rotating Cu drum, quenching ~2 kg alloy per run. Tested on Al-4 at.% Fe alloy. (QT: 3g.)

38. R. WANG, "A Rapid Quenching Technique for High Temperature Materials", *Rev. Sci. Instrum.* **41** (1970) 1233-4.

    Described hammer-and-anvil device for quenching alloys melted in an arc furnace. Tested to show metastable cph phase in Ag-25.7 at.% Ge and TSSE in *Ag*-Cu. (QT: 5b.) cf [396].

39. R. H. WILLENS and E. BUEHLER, "Rapid Quenching of Reactive and Refractory Alloys from the Liquid State", *Trans. Met. Soc. AIME* **236** (1966) 171-4.

    Described adaption of an earlier device [26] using RF concentration to melt on a cooled Ag hearth. Retained several refractory carbides and aluminides in high temperature, superconducting, forms. (QT: 1e.)

3.3. Process mechanisms

[See also refs 31, 208, 355, A1, A5, A22, A36, A61a, A62, A67]

40. M. H. BURDEN and H. JONES, "Determination of Cooling Rate in Splat-Cooling from Scale of Microstructure", *J. Inst. Metals* **98** (1970) 249-52.

    Evaluated freezing velocity from interlamellar spacing of Al-$CuAl_2$ eutectic alloy splats, to yield heat transfer coefficients (assuming Newtonian cooling) and thereby dT/dt ($\sim 3 \times 10^4$ and 7×10^5 K sec^{-1} for $z \sim 30$ μm). (QT: 1a.)

41. W. A. DEAN and R. E. SPEAR in *Strengthening Mechanisms: Metals and Ceramics*, Proc. 12th Sagamore Army Materials Research Conf. 1965 (Syracuse University Press, Syracuse, New York, 1966) pp. 268-71.

    Extended power relation, found earlier for some Al alloys between dendrite arm spacing and dT/dt, to the range of splat-cooling (*Al*-Cu, *Al*-Si, $dT/dt \sim 4 \times 10^7$ K sec^{-1}).

42. D. R. HARBUR, J. W. ANDERSON, and W. J. MARAMAN, "Rapid Quenching Drop Smasher", *Trans. Met. Soc. AIME* **245** (1969) 1055-61.

    Reported measurements of piston closure velocity v and dT/dt for piston-and-anvil apparatus (QT: 6e) testing Al, Pb, Pb-Sn and Ag-Cu alloys ($v = 12$ ft sec^{-1}, $z = 88$ and 140 μm, $dT/dt \sim 2.8 \times 10^4$ to 1.2×10^6 K sec^{-1}). See also *Mach. Des.* **38** (26) (1966) p. 25.

43. H. JONES, "Cooling Rates in Freezing Finite Slabs", *Mater. Sci. Eng.* **5** (1970) 297-9.

    Generalized Ruhl's numerical calculations [50] for Fe freezing on Cu, of average dT/dt as a function of z. Analytical support is given for the relation $dT/dt \propto z^{-2}$ for ideal cooling.

44. H. JONES, "Cooling, Freezing and Substrate Impact of Droplets formed by Rotary Atomization", *J. Phys. D: Appl. Phys.* **4** (1971) 1657-60.

    Calculations showed that negligible cooling or freezing normally takes place prior to impact and that freezing has normally progressed negligibly by the time spreading is complete. Attribution of arrest of spreading to exhaustion of kinetic energy by viscous deformation however predicts too small a terminal thickness.

45. K. LÖHBERG and H. MÜLLER, "Extreme Supercooling of Rapidly Quenched Melts of Cu and Cu Solid Solutions and their Microstructures", *Z. Metallk.* **60** (1969) 231-7 (in German).

    Reported that liquid Cu and Cu-Ni alloys cooled by a shock-tube technique in vacuum (QT: 1i) undercooled by 106 to 135 K, yielding grain sizes only one-tenth of slowly cooled but more undercooled melts. Increased nucleation was attributed to increased cavitation at the freezing rate at high cooling rates (measured $dT/dt \sim 10^5$ K sec^{-1} by radiation pyrometry). See also [46].

46. K. LÖHBERG and H. MÜLLER, "Temperature Measurements During High Rate Cooling of Metallic Melts", *Fizika* **2** Suppl. 2 (1970) 4 (abstract only).

    Reported radiation pyrometric measurements showing undercooling in Cu-Ni and dT/dt as high as 1.5×10^6 K sec^{-1} for Al ($z = 20$ μm) using shock tube in vacuum. (QT: 1i and see also [45].)

47. H. MATYJA, B. C. GIESSEN, and N. J. GRANT, "The Effect of Cooling Rate on the Dendrite Spacing in Splat-Cooled Al Alloys", *J. Inst. Metals* **96** (1968) 30-2.

    Reported measurements from transmission electron micrographs of dendrite spacings in nearly eutectic *Al*-Si, -Pd, -Fe, -Cu and -Ni alloys, fitted to the power relation with dT/dt [41]. Estimated $dT/dt \sim 2 \times 10^8$ K sec^{-1} for $z = 2$ μm.

48. I. S. MIROSHNICHENKO and V. O. ZAKHAROV, "Determination of Supercooling of Metallic Melts on Cooling at a High Rate", *Ind. Lab.* **35** (1969) 362-3 (from *Zavodskaya Lab.* **35** (1969) 302-4).

    Reported immersed thermocouple measurements of dT/dt (9.7×10^4 K sec^{-1}) and supercooling (198 K) for Al-4% Cr with $z = 130$ μm (also for Bi-Sb alloys) using two-piston apparatus. (QT: 7d.)

49. P. PREDECKI, A. W. MULLENDORE, and N. J. GRANT, "A Study of the Splat Cooling Technique", *Trans. Met. Soc. AIME* **233** (1965) 1581-6.

Reported measurements of impact velocity (~ 1000 ft sec^{-1}) and of dT/dt (1.5 to 3×10^7 K sec^{-1} for Al, 1 to 5×10^8 K sec^{-1} for Ag and ~ 10^6 for Au-14 at.% Sb with $z \sim 1$ μm), using a gun technique. (QT: 1d.)

50. R. C. RUHL, "Cooling Rates in Splat Cooling", *Mater. Sci. Eng.* **1** (1967) 313-20.

Reported finite-difference calculations of dT/dt (10^4 to 10^{10} K sec^{-1}) as a function of several variables, confirming that splat thickness z and quality of thermal contact with the substrate are normally most important. Established limiting conditions for Newtonian, intermediate and ideal cooling.

3.4.A. As-quenched microstructure

[See also refs. 27, 41, 42, 45, 47, 127, 151, 171, 179, 181, 215, 236, 273, 276, 278, 302, 303, 347, 349, 354-6, 363-5, 367, 369, 382, 384, 387, 391, 393-4, 397, A2-4, A12, A13, A16, A21, A23, A25-7, A30, A31, A36-8, A40, A45, A48, A54, A56, A61a, A62]

51. H. AHLBORN and D. MERZ, "Production, Structure and Properties of a Rapidly Solidified Al Alloy Containing 8 wt% Fe—Part I. Production and Structure", *Aluminium* **47** (1971) 671-7 (in German). See *Metals Abs.* **5** No. 7 (1972) 11-0517.

Reported metallographic and TEM studies of the effect of process variables on the microstructure of Al-8 wt% Fe quenched from the melt. (QT: 4d.) See [346] for Part II and also [363].

52. E. BABIĆ, E. GIRT, R. KRSNIK, B. LEONTIĆ, and I. ZORIĆ, "Vacancy Induced Residual Resistance in Ultrarapidly Quenched Pure Al", *Phys. Letters* **33A** (1970) 368-9.

Reported linear relationship between lattice parameter and resistivity attributable to vacancies for Al quenched from the melt at different rates by a twin-roll method. (QT: 9b.) Apparent vacancy concentration was 40 to 60% higher from lattice parameter than resistivity. See also [384].

53. R. W. BALLUFFI and R. O. SIMMONS, "On Vacancy Concentrations in Al Quenched from the Liquid State", *Acta Metallurgica* **12** (1964) 957-8.

A comment on [89], showing that there is no discontinuity in vacancy concentration at the melting point when values obtained [89] by quenching molten Al are compared with *equilibrium* measurements for the solid state.

54. G. BEGHI, R. MATERA, and G. PIATTI, "Characteristics and Applications of Ultrarapid Solidification of Metallic Alloys", *La Metall. Ital.* **60** (1968) 444-8 (in Italian).

Reported TSSE of Mn in Al to 4% Mn and morphological changes in a number of eutectic Al alloys. (*Al*-Ca, -Ce, -Y, -Sb and -Fe), obtained with a two-piston apparatus. (QT: 7c.)

55. W. E. BROWER, R. STRACHAN, and M. C. FLEMINGS, "Effect of Cooling Rate on Structure of Ferrous Alloys", *Cast Metals Res. J.* **6** (1970) 176-80.

Showed effect of dT/dt on microstructure for Fe-25% Ni, 440C and 4340 alloys confirming power relation found previously [41] for Al alloys, and showing it also applies to SiO_2 inclusion size (in a Fe-O-Si alloy). Used piston-and-anvil apparatus (QT: 6g), measuring dT/dt (~10^5 to 10^6 K sec^{-1}) by optical pyrometry and piston velocity (up to 200 mph) by photocell and oscilloscope.

56. M. H. BURDEN and H. JONES, "The Mechanism of Structure Formation in Splat-Cooled Al-Fe Alloys", *Fizika* **2** Suppl. 2 (1970) 17.1-17.6. Discussion 17.7.

Discussed possible mechanisms of the microstructural transition and hardening reported earlier [355] for *Al*-Fe alloys made by a gun technique. (QT: 1a.)

57. P. ESSLINGER, "Properties of Al alloys after Very Rapid Solidification I. Microstructure", *Z. Metallk.* **57** (1966) 12-19 (in German).

Showed by using wedge-shaped chill moulds that metastable effects (morphological change in Al-Cr-Si alloys) are established at $dT/dt > 10^3$ to 10^4 K sec^{-1}. See also [352, 353].

58. P. L. FERRAGLIO, K. MUKHERJEE, and L. S. CASTLEMAN, "First and Second Order Phase Changes in Splat-Cooled Au-Cd and Au-Zn Alloys", U.S. Clearinghouse Fed. Sci. Tech. Inform. AD 710807 (1969). See *Chem. Abs.* **74** (1971) 13451y.

Reported XRD and TEM studies on equiatomic Au-Cd and Au-Zn quenched from the melt using a shock-tube method. A substantial increase in superlattice line intensity was tentatively ascribed to preferential formation of sublattice vacancies. A modulated structure and a periodically-faulted martensitic-like phase were observed in the AuZn. See also [267, 286].

59. P. FURRER, T. R. ANANTHARAMAN, and H. WARLIMONT, "Electron-Microscopic Evidence for Heavy Faulting in Ag-Ge Alloys on Rapid Solidification", *Phil. Mag.* **21** (1970) 873-7.

Showed directly the heavy faulting in Ag-5 to 22 at.% Ge alloy foils (z up to 15 μm) made by a gun technique, found earlier [81] by XRD.

60. P. FURRER and H. WARLIMONT, "Electron-Microscopic Examination of Splat-Cooled Foils", in Proc. 7th Internat. Congr. on Electron Microscopy, Grenoble (1970), pp. 507-8.

Showed the grain structure of extended solid solutions of up to 4 at.% Fe in Al made by a gun technique. Strain contrast within grains was

attributed to solute-vacancy clustering. Heat-treatment precipitated metastable $FeAl_6$ at grain boundaries. See also *Z. Metallk.* **64** (1973) in press.

61. W. HILLER, "Refining by Electron Beam Remelting", *Met. Contr. Mecan.* (*La Metallurgie*) **100** No. 1 (1968) pp. 35-6 (in French). See *Metals Abs.* **2** (1969) 43-0004, -0043, -0078.

Reported microstructural refinement and enhanced mechanical properties for Al-11% Si and Al-6% Mn by electron beam surface remelting (QT: 11b) compared with the parent cast alloys. See also [68].

62. K. A. JACKSON, "Comment on 'Defects in Al Quenched from the Liquid State'", *Acta Metallurgica* **13** (1965) 1081-3.

Argued on the basis of solidification theory that vacancy concentration should be *decreased* on quenching the melt, not *increased* as found [89] for Al. Showed that the results [89] give this decrease if *uncorrected* for possible vacancy loss to the surfaces and if compared with *equilibrium* measurements for the solid state.

63. A. R. KAUFMANN and W. C. MULLER, "Fine Grain Size in Be by Splat Cooling", in *Beryllium Technology*, Vol. 1 (Gordon and Breach, New York, 1966) pp. 629-46.

Reported grain sizes of 1 to 10 μm for Be splats made by a rotating electrode method (QT: 4a), producing on consolidation an effective grain size of ~7 μm giving rise to improved mechanical properties compared with samples consolidated from conventional Be powder.

64. A. KIRIN, A. TONEJC, and A. BONEFAČIĆ, "Change in the Lattice Parameter of Al under the Influence of Rapid Quenching from the Liquid State", *Scripta Metall.* **3** (1969) 943-6.

Reported an apparent increase in value of lattice parameter with increasing thickness from 4 to 70 μm of Al flake made by a two-piston method (QT: 7b), no value reaching literature values for annealed Al. Effect attributed to increased retained vacancy concentration with increasing cooling rate for thinner flakes.

65. K. KRANJC and M. PAIĆ, "X-ray Microradiography of Flakes of Al-Fe Alloys Quenched Rapidly from the Melt", *Metallograghy* **2** (1969) 337-47.

Considered the problem of distinguishing between contrast in X-ray contact microradiographs due to variations in thickness or in alloy concentration. Room for improvement in a splat-cooling technique was indicated by the detection of some Fe-rich inclusions in some Al-Fe alloy samples.

66. R. KUMAR and A. N. SINHA, "Metallography of Rapid Solidification", *Trans. Indian Inst. Metals* **21** No. 1 (1968) 9-12.

Reported on metallographic structure and XRD behaviour of Al and Sb rapidly solidified by a rotating crucible method (QT: 4b). See [88] for comment.

67. E. LAINE and I. LÄHTEENMÄKI, "Structure and Microstructure Study on Splat-Cooled Cd", *J. Mater. Sci.* **6** (1971) 1418-21.

Reported grain size of <5 to ~ 10 μm, preferred orientation and decreased lattice parameter for Cd ($z \sim 40$ μm) made by a piston-and-anvil method (QT: 6i). Decrease of preferred orientation on annealing at 155 to 220°C as indicated by diffracted X-ray intensity gave an activation energy of 17.0 ± 1.8 kcal $mole^{-1}$. See also [A56].

68. B. LUX and W. HILLER, "The Structure of Very Rapidly Solidified Specimens of Al-Si and Al-Mn Alloys", *Prakt. Metallog.* **8** (1971) 218-25 (in German and English).

Reported microstructural refinement, morphological change and improved mechanical properties in Al-11% Si and Al-6% Mn alloys by electron beam surface remelting. (QT: 11b.) See also [61].

69. J. A. MCCOMB, S. NENNO, and M. MESHII, "Structure of Liquid-Quenched Al", *J. Phys. Soc. Japan* **19** (1964) 1691-5.

Reported that vacancy concentrations estimated from density of dislocation loops in electron micrographs, for splat-cooled Al made by a gun technique, showed no discontinuity (cf [89]) compared with equivalent solid state quenching data.

70. I. S. MIROSHNICHENKO, "Formation of the Structure of Eutectic-Type Alloys at High Cooling Rates", in *Crystallization Processes*, Ed. N. N. Sirota, F. K. Gorskii, and V. M. Varikash (Consultants Bureau, New York, 1966) pp. 61-6. From Russian original (1964) pp. 146-56.

Reported changes in morphology of Fe-C, Al-Cu and Pb-Sn eutectic alloys on cooling melts at dT/dt up to 5×10^5 K sec^{-1} using twin (QT: 6a) and single substrate methods.

71. I. S. MIROSHNICHENKO, "Structure Formation in Cast Irons during Crystallization at a High Cooling Rate", Termodinam. i Fiz. Kinetika Strukturoobrazov. v Stali i Chugune. Tula, 1967, pp. 111-7 (in Russian) See *Chem. Abs.* **70** (1969) 22124r.

Reported microstructure of Fe-2.2 to 5.5% C crystallized at dT/dt up to 10^6 K sec^{-1} by a twin-substrate method.

72. I. S. MIROSHNICHENKO, "Formation of Quasi-Eutectic Structures in Al-$CuAl_2$ Alloys", *Russian Metallurgy* (*Metally*), **1968** No. 5, pp. 128-32. (From *Izvest. Akad. Nauk SSSR, Metally* **1968** No. 5, pp. 188-93.)

Used twin substrate method (QT: 6a) ($z = 30$ to 200 μm) and wedge-moulds to extend the composition

range of eutectic formation and change its morphology at dT/dt up to 10^7 K sec^{-1}.

73. I. S. MIROSHNICHENKO and A. YA. ANDREEVA, "A New Type of Eutectic Colonies in Fe-Fe_3C Alloys", *Doklady Chemistry* **182** (1968) 814-15. From *Doklady Akad. Nauk SSSR* **182** (1968) 352-3.

Reported on substructure of eutectic colonies in Fe ~ 4.2% C solidified at dT/dt of 10^5 to 10^6 K sec^{-1} between two copper plates.

74. I. S. MIROSHNICHENKO and A. YA. ANDREEVA, "Experimental Determination of Quasi-eutectic Region in Al-$CuAl_2$ Alloys", *Doklady Akad. Nauk SSSR*, **186** No. 5 (1969) English version pp. 128-30, Russian original pp. 1140-2.

Solidified Al-Cu alloys in wedge-moulds to extend eutectic formation over the range 26 to 37 wt % Cu at the highest dT/dt obtained.

75. I. S. MIROSHNICHENKO and A. YA. ANDREEVA, "On Degeneracy of Eutectic Structures", *Akad. Nauk. Ukrain. SSR, Metallofizika* **1970** No. 27, pp. 169-75 (in Russian). See *Metals Abs.* **3** (1970) 12-1220, *Chem. Abs.* **74** (1971) 5977m.

Reported and discussed effect of dT/dt (10 to $>10^6$ K sec^{-1}) on eutectic morphology in Fe-Fe_3C and Al-$CuAl_2$ eutectic alloys causing degenerate eutectics to form at $dT/dt > 10^6$ K sec^{-1}.

76. I. S. MIROSHNICHENKO and I. V. SALLI, "Structure of Cast Iron Hardened in Liquid State", *Izvest. Akad. Nauk SSSR, Otdel. Tekh Nauk, Met. i Topl.* **1961** No. 1, pp. 44-8 (in Russian). See *Chem. Abs.* **55** (1961) 19680d and *J. Iron Steel Inst.* **200** (1962) 261a.

Reported on microstructure of Fe-2.2 to 5.5 wt % C solidified at dT/dt up to 10^5 K sec^{-1}.

77. A. PRODAN and A. BONEFAČIĆ, "X-ray Study of Defects in Rapidly Quenched Al", *Fizika* **2** Suppl. 2 (1970) 29.1-29.3. Discussion 29.4-29.5.

Reported small angle X-ray scattering studies on Al samples ($z = 55$ μm) rapidly quenched from the melt, considered to indicate clusters of up to 100 vacancies.

78. P. RAMACHANDRARAO, "Structural Studies in Metals and Alloys Rapidly Cooled from the Melt", *The Banaras Metallurgist* **2** (1969) 38-40.

Summary of Ph.D. Thesis, Banaras, 1968. See [79-82, 146, 207-8, 246].

79. P. RAMACHANDRARAO and T. R. ANANTHARAMAN, "Solidification Substructures in a Sn-Pb alloy Quenched from the Melt", *Trans. Met. Soc. AIME* **245** (1969) 890-2.

Showed metallographically, transitions between diffusionless predendritic, cellular and dendritic solidification in specimens of Sn-1 wt % Pb made by a gun technique.

80. P. RAMACHANDRARAO and T. R. ANANTHARAMAN, "Study of X-ray Line Breadths in Some Fcc Metals Quenched from the Melt", *Trans. Met. Soc. AIME* **245** (1969) 892-3.

Reported for Ag quenched from the melt, X-ray line broadening, absent for Al and Pb which showed evidence of grain-boundary migration after solidification.

81. P. RAMACHANDRARAO and T. R. ANANTHARAMAN, "Formation of Faulted Close-packed Structures in Ag-Ge Alloys Quenched from the Melt", *Phil. Mag.* **20** (1969) 201-3.

Reported, for Ag-5.0 to 22.0 at. % Ge alloys made by a gun technique, X-ray line broadening indicative of heavy faulting in both fcc and metastable cph phases. See also [59, 82].

82. P. RAMACHANDRARAO, P. R. RAO, and T. R. ANANTHARAMAN, "X-ray Line Broadening in Splat-Cooled Ag and Ag-Ge Alloys", *Z. Metallk.* **61** (1970) 471-5.

Reported that integral breadth analysis of XRD profiles indicated a small domain size of ~0.1 μm for Ag and fcc Ag-7.0 at. % Ge and in addition deformation and growth faulting for cph Ag-22.0 at. % Ge, all made by a gun technique described. (QT: 1j.)

83. P. K. RASTOGI and K. MUKHERJEE, "Defects in Pb Quenched from the Liquid State", *Metall. Trans.* **1** (1970) 2115-7.

Reported resistivity measurements of vacancy concentration in Pb quenched from the melt into iced water ($dT/dt \sim 10^4$ K sec^{-1}), indicating an increase compared with literature results for Pb quenched entirely in the solid state (cf. [69, 89] for Al).

84. I. V. SALLI, "Structure of Alloys Produced by Rapid Cooling", *Liteinoe Proizvodstvo* **1958** No. 7, pp. 22-5 (in Russian). See *Chem. Abs.* **53** (1959) 1053a, *Metall. Abs.* **26** (1958-9) 492, *J. Iron Steel Inst.* **192** (1959) 321c.

Reported attempts to obtain diffusionless solidification by quenching Fe-C, Al-Si, Pb-Sn, Sn-Bi and Zn-Al alloys by an early catapult/piston-and-anvil device. (QT: 6a.)

85. I. V. SALLI, "Stable and Metastable Cast Irons", Razvitie Proizv. Kovkogo Chuguna, Nauchn.-Tekhn. Obshschestvo Mashinostr. Prom. Tr. 3ei (Tret'ei) Vses. Konf. 1960, publ. 1963, pp. 240-52 (in Russian). From *Chem. Abs.* **60** (1964) 249f.

Discussed effects of solidification at high dT/dt (~ 10^5 K sec^{-1}) such as increasing TSSE in the series *Fe*-C, *Co*-C and *Ni*-C. 22 references.

86. I. V. SALLI, in *Structure Formation in Alloys* (Consultants Bureau, New York, 1964) Section VI.3, pp. 64-75. From Russian original (Moscow, 1963).

Reviewed mainly own work (1959-61) on effects of rapid quenching of alloys from the melt (QT: 6a), with special reference to morphological changes in Fe-C alloys and TSSE.

87. D. R. SPALDING, R. E. VILLAGRANA, and G. A. CHADWICK, "A Study of Copper Distribution in Lamellar Al-$CuAl_2$ Eutectics Using an Energy Analysing Electron Microscope", *Phil. Mag.* **20** (1969) 471-88.

Reported plasmon energy loss spectrum across an Al/$CuAl_2$ interphase boundary in specimen made by piston-and-anvil technique ($dT/dt \sim 10^6$ K sec^{-1}, $z \sim 20$ to 50 μm).

88. C. SURYANARAYANA and T. R. ANANTHARAMAN, "Metallography of Rapid Solidification", *Trans. Indian Inst. Metals* **21** No. 3 (1968) 67 only.

Reported that XRD evidence [66] for a cph form of Al by quenching the melt can be attributed to AlN impurity in the specimen.

89. G. THOMAS and R. H. WILLENS, "Defects in Al Quenched from the Liquid State", *Acta Metallurgica* **12** (1964) 191-6.

Showed, by TEM, grain and defect structures in Al quenched by a gun technique. Vacancy concentration at the melting point indicated by the dislocation loop density was higher than for literature values for quenching entirely within the solid state. See [53, 62] for comments and [90, 91] for replies.

90. G. THOMAS and R. H. WILLENS, "On Vacancy Concentrations in Al Quenched from the Liquid State", *Acta Metallurgica* **13** (1965) 139-40.

Replied to [53] by arguing that original comparison [89] with *quenched* data for solid Al was more reasonable than with *equilibrium* data proposed by [53].

91. G. THOMAS and R. H. WILLENS, "Vacancy Concentrations in Quenched Al", *Acta Metallurgica* **14** (1966) 1385-90.

Replied to [62] by showing by TEM that vacancies are lost near free surfaces in quenching Al and thus must be corrected for in estimating true quenched-in vacancy concentration as in [89].

92. S. N. TIWARI, S. L. MALHOTRA, and T. R. ANANTHARAMAN, "Non-Equilibrium Solidification in a Peritectic System", *Current Science* (*India*) **39** (1970) 477-80.

Used modified gun technique (QT: 1j) to rapidly solidify Pb-15, 26 and 37 wt % Bi alloys for comparison with more slowly-solidified structures.

93. W. VANDERMEULEN and A. DERUYTTERE, "Structures Obtained in a Cu-11.8 at. % Sn Alloy Quenched from the Melt", *Fizika* **2** (1970) 8.1-8.5. Discussion 8.6.

Reported XRD and metallographic studies on Cu-11.8 at. % Sn made by both gun and piston-and-anvil techniques. Concluded that martensite observed formed from a metastable bcc phase formed first from the melt. See also [296] and cf. [94, 267, 286].

94. H. WARLIMONT and P. FURRER, "Interrelations between Metastable Phases formed by Rapid Solidification and by Martensitic Transformation", *Fizika.* **2** Suppl. 2 (1970) 26.1-26.6.

Argued that rapidly solidified and martensitically formed Cu, Ag and Au alloys have many common structural characteristics. Structures obtained in rapidly solidified alloys may form directly from the melt or by subsequent martensitic transformation of a transient phase formed directly from the melt. cf. [93, 267, 286].

3.4.B. Metastable terminal solid solubility extension (TSSE)

[See also refs. 16, 28, 31-6, 38, 39, 54, 60, 68, 82, 86, 181-2, 190-2, 199, 201, 205, 210, 215, 218, 238, 246, 259-61, 263-4, 268-75, 277, 279, 281-5, 287, 290-2, 294-5, 297-8, 300, 305, 320, 322, 328, 330, 354-5, 364-6, 369-71, 379, 382, 385, 389a, 390, 392, 402, A3, A4, A10, A12, A15, A17, A34-7, A47, A48, A51-2, A57, A59-61, A65-7]

95. T. R. ANANTHARAMAN, "On the Impact of Spark Erosion Treatment on the Structure of Co", *Z. Metallk.* **61** (1970) 760-2.

Argued that evidence [116] of formation of "δ"-Co in spark-eroded surfaces is more satisfactorily interpreted as due to gaseous (e.g. N_2) adsorption forming interstitial solid solutions or compounds. See also [201].

96. E. BABIĆ, R. KRSNIK, B. LEONTIĆ, and A. TONEJC, "Residual Resistance Measurements on Super-Saturated Metastable Alloys of Fe in Al", *Phys. Letters* **32A** (1970) 5-6.

Reported linear increase of residual resistance ratio with increasing Fe content up to 0.7 at. % in extended terminal solid solutions of *Al*-Fe alloys made by a two-piston technique ($z < 10$ μm). See also [385].

97. J. C. BAKER and J. W. CAHN, "Solute Trapping by Rapid Solidification", *Acta Metallurgica* **17** (1969) 575-8.

Showed that TSSE up to at least 5 wt % Cd in Zn occurred using a gun technique, although this alloy system has a retrograde solidus with a maximum at 2.6 wt % Cd. The sign of the implied departure from local equilibrium at the solid-liquid interface is opposite to that assumed by two theories of non-equilibrium solidification.

98. J. BLÉTRY, "The Effects of Substitution of First Series Transition Metals in Al Solid Solutions", *J. Phys. Chem. Solids* **31** (1970) 1263-72 (in French).

Reported that the measured variation of lattice

parameter with composition in extended terminal solid solutions (up to 5 at. %) of Ti, V, Cr, Mn, Fe, Co and Ni in Al prepared by splat cooling, agreed only qualitatively with theory.

99. L. M. BUROV, T. I. SHEYKO, and V. F. BASHEV, "Investigation of the Fine Structure Parameters of Al-W, Al-Mo and Al-Mn Alloys obtained at High Cooling Rates", *Phys. Metals Metallog.* **30** No. 1 (1970) 241-3. (From *Fiz. Metal. Metalloved.* **30** (1970) 222-4.)

Reported that XRD of Al-W, Al-Mo and Al-Mn extended solid solutions made by compressed air ejection on to a rotating brass cylinder ($dT/dt \sim 10^5$ to 10^6 K sec^{-1}, z up to 150 μm), indicated a coherent scattering region of 0.13 μm for Al decreasing to 0.08 μm with 2 at. % substituted W or Mo.

100. L. M. BUROV and N. I. VARICH, "Thermal Expansion of Al-Mn and Al-Cr Alloys", *Phys. Metals Metallog.* **16** No. 4 (1963) 33-6. (From *Fiz. Metal. Metalloved.* **16** (1963) 530-4.)

Measured thermal expansion coefficient from the dependence on T of the lattice parameter of *Al*-Cr and *Al*-Mn extended solid solutions containing up to 2.9 wt % Cr and 3.2 wt % Mn made by a catapult technique (QT: 2a). The solid solutions were stable for at least 4 h up to 400° C.

101. L. M. BUROV and A. A. YAKUNIN, "Formation of Strongly Supersaturated solid Solutions in Al-Mn and Al-Cr Alloys", *Russ. J. Phys. Chem.* **39** (1965) 1022-5. (From *Zhur. Fiz. Khim* **39** (1965) 1927-31.)

Measured lattice parameter and microhardness as a function of composition and dT/dt (up to 5×10^5 K sec^{-1}) for extended solid solutions of Mn and Cr in Al (up to 9.93 wt % Al, 4.2 wt % Cr) made by a catapult technique (QT: 2a). Microhardness differences between microstructures were related to extended and depleted solid solutions.

102. L. M. BUROV and A. A. YAKUNIN, "Effect of the Rate of Cooling on the Composition of Solid Solutions in Binary Alloys Based on Al", *Russ. J. Phys. Chem.* **42** (1968) 540-1. (From *Zhur. Fiz. Khim.* **42** (1968) 1028-30.)

Reported increased limit of TSSE with increasing dT/dt for Cr, W, Mo, Zr, and V in Al by catapulting on to stationary ($dT/dt \sim 10^6$ K sec^{-1}, $z = 50$ μm) substrates, or by using a gun technique ($dT/dt \sim 10^7$ to 10^8 K sec^{-1}, $z \sim 5$ to 10 μm).

103. C. C. CHAO, P. DUWEZ, and C. C. TSUEI, "Metastable fcc Fe-Rh Alloys and the Fe-Rh Phase Diagram", *J. Appl. Phys.* **42** (1971) 4282-4.

Reported a tentative Fe-Rh phase diagram on the basis of lattice parameter and of Fe^{57} Mössbauer spectra of extended fcc solid solutions (< 40 at. % and > 60 at. %) of Rh in Fe made by a gun technique ($z = 50$ μm).

104. J. DIXMIER and A. GUINIER, "Production of New Phases by Ultrarapid Quenching of Liquid Alloys", *Mem. Sci. Rev. Met.* **64** (1967) 53-8 (in French). See *Chem. Abs.* **68** (1968) 32573j.

Reported TSSE up to 40 at. % Ag in Al and formation of an AS phase in Au-20 to 40 % Si, made by a two-piston method. (QT: 7b.)

105. P. DUWEZ, R. H. WILLENS, and W. KLEMENT, "Continuous Series of Metastable Solid Solutions in Ag-Cu Alloys", *J. Appl. Phys.* **31** (1960) 1136-7.

Reported XRD evidence for complete extension of solid solubility in Ag-Cu alloys made by shock tube methods with stationary and rotating cylinder substrates. (Table Ia, entries 1a and 3a.)

106. P. DUWEZ, R. H. WILLENS, and W. KLEMENT, "Metastable Solid Solutions in the GaSb-Ge Pseudobinary System", *J. Appl. Phys.* **31** (1960) 1500 only.

Reported XRD evidence for complete solid solubility extension in GaSb-Ge alloys made by shock tube methods (QT: 1a, 3a.)

107. B. C. GIESSEN, R. RAY, and S. H. HAHN, "Extensive Interstitial Solid Solutions of Metals in Metals", *Phys. Rev. Letters* **26** (1971) 509-12.

Reported XRD studies and density measurements indicating extended solid solutions of Cu interstitially in Y, obtained in splat-cooled foils 0.1 to 5 μm thick ($dT/dt \sim 10^8$ K sec^{-1}).

108. M. ITAGAKI, B. C. GIESSEN, and N. J. GRANT, "Supersaturation in Rapidly Quenched Al-Rich Al-Si Alloys", *Trans. Amer. Soc. Metals* **61** (1968) 330-5.

Reported XRD and TEM evidence for extended solid solutions of up to 11 at. % Si in Al, made by a gun technique ($z = 1$ to 5 μm, $dT/dt \sim 10^7$ to 10^9 K sec^{-1}). Annealing at 100 to 250° C produced fine uniform Si precipitation.

109. C. JANSEN, B. C. GIESSEN, and N. J. GRANT, "Terminal Supersaturation in Splat Cooled Alloys of Al with Transition Elements and Cu", *J. Metals* **20** (1968) 91A. Abstract only.

Reported TSSE of Co, Cu, Fe, Mn, Ni and Pd in Al by splat cooling at $dT/dt \gg 10^7$ K sec^{-1} in argon. See also [354].

110. H. KANEKO and J. IKEUCHI, "Abnormal Structure of Metals Formed", Proc. 1st Internat. Conf. on Electron Discharge Machining (Japan EDM Soc., Tokyo, 1965) p. 23 *et seq.*

Reported TSSE up to 75 wt % Ag and up to 35 wt % Cu in Al by an electrodischarge technique. (QT: 11a.)

111. A. KIRIN and A. BONEFAČIĆ, "Supersaturation in Rapidly Quenched Al-Rich Al-Sn Alloys", *Scripta Metall.* **4** (1970) 525-8.

Reported XRD evidence for TSSE of up to 0.26

at. % Sn in Al made by gun and two-piston methods (z = 1 to 20 μm).

112. W. KLEMENT, "Ni-Rich Solid Solutions in Binary Alloys with Sn, Ge and Si", *Canad. J. Phys.* **40** (1962) 1397-1400.

Reported XRD evidence for TSSE of up to 12 at. % Sn, 20 at. % Ge and 15 at. % Si in Ni, made by a rotating substrate method. (QT: 3a.)

113. W. KLEMENT, "Solid Solutions in Au-Co and Cu-Co Alloys", *Trans. Met. Soc. AIME* **227** (1963) 965-70.

Reported TSSE up to 42 at. % Co in Au, 15 at. % Co in Cu and 25 at. % Cu in Co made by a rotating substrate method (QT: 3a), z up to 10 μm), and also for metastable solid solutions in multiphase alloys of intermediate compositions.

114. W. KLEMENT, "Solid Solutions in Cu-Fe Alloys Quenched Rapidly from the Melt", *Trans. Met. Soc. AIME* **233** (1965) 1180-2.

Reported TSSE up to 20 at. % Fe in Cu and 15 at. % Cu in Fe, made as in [113].

115. W. KLEMENT and H-L. LUO, "Metastable Solid Solutions in Ag-Pt Alloys", *Trans. Met. Soc. AIME* **227** (1963) 1253-4.

Reported XRD evidence for complete extended solid solutions in Ag-Pt alloys made by a rotating substrate method. (QT: 3a.)

116. E. KRAINER and J. ROBITSCH, "Evidence of a New phase by Spark Erosion Treatment of Co", *Z. Metallk.* **61** (1970) 350-4 (in German).

Reported XRD evidence for formation of hexagonal high-temperature form of Co, with a hardness of 462 kg mm^{-2}, by spark-erosion. See also [95, 201].

117. A. K. KUSHNEREVA and I. V. SALLI, "The Metastable Crystallization of Binary Alloys", *Metallofizika Desp. Mezhved,* **56,** 1968 (22) 115-20 (in Russian). See *Metals Abs.* **2** (1969) 11-0723, *Chem. Abs.* **72** (1970) 103123h.

Reported TSSE up to 13% Mn, 5% Zr and 9% Ce in Al and 6% Pb in Cu, solidified at a dT/dt of 10^6 K sec^{-1}.

118. A. K. KUSHNEREVA and I. V. SALLI, "Formation of Supersaturated Primary Solid Solutions in the Systems Al-Si and Al-Ge", *Izv. Akad. Nauk. SSSR, Neorg. Mater.* **6** (1970), English version pp. 1644-5, Original Russian pp. 1867-8.

Reported TSSE up to 11 at. % Si and 7 at. % Ge in Al at $dT/dt \sim 10^6$ K sec^{-1} obtained by method [36]. In addition, two metastable simple cubic phases were detected at 20 to 28 and 40 to 45 at. % Ge in Al. (See also [153].)

119. L. P. LIMINA, "Some Features of the Solidification of Alloys at Ultrarapid Cooling Rates", *Russian Metallurgy* (*Metally*) **1968** No. 2, pp. 95-99 (From *Izv. Akad. Nauk SSSR, Metally* **1968** No. 2, pp. 147-52.)

Reported XRD evidence that increasing dT/dt (range 10^3 to 10^6 k sec^{-1}, rotating substrate method, QT: 3a) TSSE up to 6% Zn and 13% Mn in Al. Also reported effect of annealing at 200 to 450°C on lattice parameters of Al-5, 10 and 15% Mn extended solid solutions.

120. R. K. LINDE, "Enthalpy of Solid Solution for a Metastable Ag-Cu Alloy", *J. Phys. Chem.* **69** (1965) 4407-8.

Reported calorimetric measurement of enthalpy of solid solution of metastable Ag-25 at. % Cu extended solid solution [284] as 1150 ± 200 cal $(g\text{-atom})^{-1}$.

121. R. K. LINDE, "Lattice Parameters of Metastable Ag-Cu alloys", *J. Appl. Phys.* **37** (1966) 934 only.

Reported lattice parameters as a function of composition for Ag-Cu completely extended solid solutions made by a gun technique (QT: 1a), $z \sim 1$ μm, $dT/dt > 10^6$ K sec^{-1}).

122. H-L. LUO, "Lattice Parameters of Fe-Rich Fe-Ga Alloys", *Trans. Met. Soc. AIME* **239** (1967) 119-20.

Reported retention of αFe solid solution for up to 50 at. % Ga in Fe-Ga alloys by a gun technique [26], and evidence for BiF_3-type ordering at 25-30 at. % Ga.

123. H-L. LUO, C. C. CHAO, and P. DUWEZ, "Metastable Solid Solutions in Aluminium-Magnesium Alloys", *Trans. Met. Soc. AIME* **230** (1964) 1488-90.

Reported TSSE up to 36.8 at. % Mg in Al and to 22.6 at. % Al in Mg by a gun technique [26].

124. H-L. LUO and P. DUWEZ, "Fcc Co-Rich Solid Solutions in Binary Alloys with Al, Ga, Si, Ge and Sn", *Canad. J. Phys.* **41** (1963) 758-61.

Reported TSSE up to 17.2 at. % Al, 18.2 at. % Ga, 13 at. % Si, 17.4 at. % Ge and 5 at. % Sn in Co by a gun technique.

125. H-L. LUO and P. DUWEZ, "Solid Solutions of Rh with Cu and Ni", *J. Less Common Metals* **6** (1964) 248-9.

Reported complete solid solubility extension in Rh-Cu and Rh-Ni alloys by a gun technique ($z \sim 10$ μm). Two Rh-Cu alloy solid solutions decomposed at 600 and 800°C within seven to ten days, whereas Rh-Ni solid solutions were stable.

126. I. S. MIROSHNICHENKO, "Crystallization of Co-C and Ni-C Alloys at High Cooling Rates", *Izv. VUZ Tsvetnye Met.* **4** No. 1 (1961) 128-33 (in Russian). See *Chem. Abs.* **55** (1961) 17434d; *Metall. Abs.* **29** (1961-2) 340.

Reported TSSE of C to 1.65% in Co and to 1.85% in Ni at $dT/dt \sim 10^5$ K sec^{-1} (z = 50 to 200 μm). For Co-4.4% C and Ni-3.5% C all carbon was retained as carbides without formation of graphite.

127. I. S. MIROSHNICHENKO, "Crystallization of Eutectic Alloys at High Cooling Rates", in Symposium on "Crystallization and Phase Transformations", *Izvest. Akad. Nauk Beloruss. SSR, Minsk* 1962, pp. 133-45 (in Russian). See *Chem. Abs.* **58** (1963) 11046g.

Reported TSSE in *Ni*-C, *Co*-C, *Al*-Mn, *Al*-Cr and Sn-Sb and change in morphology in Fe-C eutectic alloys using early catapult/piston-and-anvil device (QT: 6a) (dT/dt up to 10^6 K sec^{-1}, $z = 30$ to 200 μm).

128. I. S. MIROSHNICHENKO, "Broadening of the Region of Primary Solid Solutions in Alloys of Eutectic and Peritectic Types" in *Crystallization Processes*, Ed. N. N. Sirota, F. K. Gorskii, and V. M. Varikash (Consultants Bureau, New York, 1966) pp. 55-9. (From Russian original (1964) pp. 138-45.)

Reported TSSE in *Ni*-C, *Co*-C and *Al*-Mn alloys solidified at $dT/dt \sim 10^6$ K sec^{-1}, including three step changes with increasing dT/dt (range 1 to 10^6 K sec^{-1}) for Al-Mn interpreted as metastable limits in the presence of $MnAl_6$, $MnAl_4$ and $MnAl_3$ phases.

129. I. S. MIROSHNICHENKO, "The Influence of the Rate of Cooling during Crystallization on Liquation Microinhomogeneity and Composition of Solid Solutions in Al-Mg Alloys", *Doklady Phys. Chem.* **164** (1965) 647-9 (From *Doklady Akad. Nauk SSR* **164** No. 1 (1965) 137-9).

Reported that *minimum* solute concentration (as indicated by lattice parameter measurements) in the dendrite arms of Al-Mg extended solid solutions decreased slightly with increasing dT/dt (range 10 to 10^6 K sec^{-1}) during solidification.

130. I. S. MIROSHNICHENKO, "The Effect of Cooling Rate during the Crystallization of Solid Solutions on the Composition of the Axial Parts of the Dendrite Branches", in *Growth and Imperfections of Metallic Crystals*, Ed. D. E. Ovsienko (Consultants Bureau, New York, 1968) pp. 255-9. (From Russian original (1966) pp. 320-5.)

Extension of [129], showing in addition "diffusionless" solidification of *Al*-Mg alloy extended solid solutions at dT/dt of 10^6 to 10^7 K sec^{-1}.

131. I. S. MIROSHNICHENKO, "Crystallization of Alloys at High Cooling Rate and the Phase Diagram", in *Teor. Eksp. Metody Issled. Diagramm Sostoyaniya Metal. Sist.*, Dokl. Soveshch, 1967, Ed. N. V. Ageev (Moscow, 1969), pp. 280-4 (in Russian). See *Chem. Abs.* **73** (1970) 124302b.

Reviewed effect of high dT/dt of alloys on their phase diagram (21 references).

132. I. S. MIROSHNICHENKO, "Crystallization of Alloys at High Cooling Rates", in *Mechanism and Kinetics of Crystallization* (Minsk, 1969) pp. 16-23 (in Russian). See *Metals Abs.* **4** (1971) 12-0718, *Chem. Abs.* **74** (1971) 16376r.

Reviewed occurrence of TSSE and of MCS and AS phases by solidification at high dT/dt (10^4 to 10^8 K sec^{-1}) and the practical aspects of non-equilibrium solidification.

133. I. S. MIROSHNICHENKO and G. P. BREKHARYA, "Influence of Cooling Rate on the Supercooling of Metal Melts", *Phys. Metals Metallog.* **29** No. 3 (1970) 233-4. (From *Fiz. Metal. Metalloved.* **29** (1970) 664-6.)

Reported linear relationship between measured supercooling (140 to 300 K) and measured dT/dt (2×10^4 to 3×10^5 K sec^{-1}) for Al-6.9% Mn as well as single measurements for *Al*-Cr, *Al*-Mg, *Al*-Cu, Bi-Sb and Al and Bi of different purities. (QT: 7d.)

134. I. S. MIROSHNICHENKO and I. V. SALLI, "The Lines of Metastable Equilibrium in Binary System Diagrams", *Izv. VUZ Chernaya Met.* **1960** No. 8, pp. 104-9 (in Russian). From *J. Iron Steel Inst.* **200** (1962) 418c-419a (title only).

Discussed TSSE (at $dT/dt \sim 10^5$ K sec^{-1}) in Pb-Sn, Bi-Sn, Al-Si, Al-Zn, Fe-C, Ni-C, Al-Mn and Al-Cr alloys in relations hypothetical free energy diagrams and extended boundaries of phase fields (e.g. liquidus and solidus) on phase diagrams.

135. I. S. MIROSHNICHENKO and I. V. SALLI, "Structure of Liquid Alloys with High Rates of Supercooling", *Izv. Akad. Nauk. SSSR, Met. i Topl.* **1961** (Tekhn) No. 3, pp. 130-1 (in Russian). See *Metall. Abs.* **29** (1961-2) 769.

Discussed formation of metastable TSSE (e.g. in *Al*-Mn, *Al*-Cr, *Ni*-C, *Co*-C) and relation to solidus extension on phase diagrams and clustering in the liquid state.

136. I. S. MIROSHNICHENKO and G. A. SERGEEV, "Some Features of the Expansion of the Solid Solution Zone in Eutectic and Peritectic Alloys", *Russ. J. Phys. Chem.* **43** (1969) 873-4. (From *Zhur. Fiz. Khim.* **43** (1969) 1571-2.)

Discussed TSSE in *Al*-Mn, *Ni*-C and *Al*-Cr alloys in relation to metastable extensions of their phase diagrams.

137. I. S. MIROSHNICHENKO and G. A. SERGEEV, "Non-Equilibrium Crystallization of Solid Solutions" in *Mechanism and Kinetics of Crystallization* (Minsk, 1969) pp. 40-6 (in Russian). See *Metals Abs.* **4** No. 6 (1971) 12-0720.

Discussed effect of dT/dt (10 to 10^7 K sec^{-1}) on microsegregation, microstructure and composition in Bi-Sb, Ge-Si and Cu-Ni solid solutions, diffusionless solidification (one solid solution only) forming only at the highest dT/dt.

138. K. MUTSUZAKI, M. SUZUKI, and E. KAWAI, "On the Formation of the Continuous Solid Solution on

the Surfaces Eroded by Electrical-discharge Machining in Ag-Cu Binary Systems", *J. Jap. Inst. Metals* **27** (1963) 424-7 (in Japanese). Abstract in English.

Reported complete solid solubility extension in electro-discharge machined surfaces of Ag-Cu alloy samples.

139. S. NAGAKURA, S. TOYAMA, and S. OKETANI, "Lattice Parameter and Structure of Ag-Cu Alloys Rapidly Quenched from the Liquid State", *Acta Metallurgica* **14** (1966) 73-5.

Reported dependence of lattice parameter on composition for the continuous solid solution formed by quenching Ag-Cu alloys by a rotating substrate method (QT: 3a). Electron microscopy showed differences in precipitation behaviour from solid-solid quenched alloys. See also [270].

140. L. R. NEWKIRK and C. C. TSUEI, "Mössbauer Study of BiF_3-type Ordering in Metastable Fe-Ga Alloys", *J. Appl. Phys.* **42** (1971) 5250-3.

Reported that Mössbauer study indicated BiF_3 ordering in Fe-25 (possibly down to 20) at.% Ga extended solid solution made by a piston-and-anvil method. (QT: 6b, $z \sim 60$ μm.)

141. I. I. PAPIROV, G. F. TIKHINSKIY, and V. A. FINKEL, "Diffusionless Phase Transformation in the Alloy Be-8 at.% Ni", *Phys. Metals Metallog.* **15** No. 3 (1963) 120-2. (From *Fiz. Metal. Metalloved.* **15** (1963) 462-5.)

Reported TSSE in Be-8 at.% Ni alloy quenched from the melt by spraying on to a cooled Cu plate. Decomposition commenced within 2 h at 600°C.

142. I. I. PAPIROV, G. F. TIKHINSKIY, and V. A. FINKEL, "Quenching of Be-Ni Alloys", *Phys. Metals Metallog.* **17** No. 4 (1964) 132-3. (From *Fiz. Metal. Metalloved.* **17** (1964) 613-4.)

Extended [141] to alloys containing 5 to 36 wt% Ni sprayed on to the inside of a rotating Cu cylinder (cf. QT: 3a, $dT/dt \sim 10^6$ K sec^{-1}) giving $z \sim 10$ μm.

143. A. F. POLESYA, L. P. SLIPCHENKO, L. M. BUROV, V. N. GUDZENKO, and V. I. DEMESHKIN, "Effect of Cooling Rate on the Structure Formation in Fe-W and Fe-Mo Alloys", *Izv. VUZ Chernaya Met.* **1971** No. 9, 114-7 (in Russian). See *Metals Abs.* **5** No. 3 (1972) 11-0176.

Reported TSSE to 18.5 and 20.8 at.% W and to 32 and 40.6 at.% Mo in Fe at dT/dt of 10^5 and 10^7 K sec^{-1} respectively compared with maximum equilibrium values (13 at.% W and 26 at.% Mo) obtained at 10^3 K sec^{-1}.

144. A. F. POLESYA and A. I. STEPINA, "Formation of Supersaturated Ternary Solid Solutions from Melts Cooled at High Rates", *Phys. Metals. Metallog.* **27** No. 5 (1969) 122-6. (From *Fiz. Metal. Metalloved.* **27** (1969) 885-9.)

Reported that TSSE of W, Mo and Zr additions in *Al*-Mn and *Al*-Cr occurred to a greater extent than in their binary alloys with Al. (QT: 3a, $dT/dt \sim 10^6$ to 10^7 K sec^{-1}, $z \sim 20$ to 60 μm.)

145. A. F. POLESYA and A. I. STEPINA, "Compositions of Solid Solutions of Al-Mn-Fe, Al-Mn-Co and Al-Mn-Ni Alloys after Rapid Crystallization", *Izv. VUZ Tsvet. Met.* **13** No. 1 (1970) 117-20 (in Russian). See *Chem. Abs.* **73** (1970) 49157c; *Metals Abs.* **3** No. 7 (1970) 11-0443.

Reported TSSE ($dT/dt \sim 10^6$ to 10^7 K sec^{-1}) to $\leqslant 0.5$ wt% Fe and $\leqslant 0.15$ wt% Co or Ni added to *Al*-Mn alloys. Precipitation on annealing of *Al*-Mn-Fe alloys involved Fe before Mn.

146. P. RAMACHANDRARAO and T. R. ANANTHARAMAN, "Impact of Liquid Quenching on Al-Ag Alloys", *Current Science (India)* **37** (1968) 124-6.

Reported TSSE in *Al*-Ag alloys and an increase in axial ratio for the ζ phase. (QT: 3a, z up to 15 μm.)

147. R. C. RUHL and M. COHEN, "A New Metastable cph Phase in the Fe-C system", *Acta Metallurgica* **15** (1967) 159-60.

Reported formation of a cph Fe solid solution containing 3.3 to 4.2 wt% C (QT: 1h) in ternary alloys containing Si, Mn, Cr and Ni as well as in binary Fe-C alloys, related to cph Fe forming at high pressure. (See also [149].)

148. R. C. RUHL and M. COHEN, "Metastable Extensions of C Solubility in Ni and Co", *Scripta Metall.* **1** (1967) 73-4.

Reported TSSE to 7.4 at.% C in Ni and to 5.3 at.% C in Co. The decrease in TSSE of C along the series Ni, Co and Fe is related to carbide free energy of formation. (QT: 1h.)

149. R. C. RUHL and M. COHEN, "Splat Quenching of Fe-C Alloys", *Trans. Met. Soc. AIME* **245** (1969) 241-51.

Reported formation of cph Fe solid solutions in Fe-3.8 to 4.8 wt% C alloys (QT: 1h), decomposing to martensite and ϵ-carbide after 1 h at 140 to 200°C, and then αFe and Fe_3C after 1 hr at 330 to 460°C. The effect of ternary additions Si, Co, Cr, Mn, Ni and Ru was also studied.

150. R. C. RUHL and M. COHEN, "Splat Quenching of Fe-Ni-B Alloys", *Trans. Met. Soc. AIME* **245** (1969) 253-7.

Reported TSSE in Fe-Ni-B alloys (QT: 1h) *not* obtained in the binaries Fe-Ni and Fe-B. Added B increased austenite retention in Fe-Ni alloys, the B substituting both interstitially and substitutionally simultaneously in austenitic and martensitic phases.

151. I. V. SALLI, "Some Regularities of the Appearance of Metastable Systems of Fe-C Alloys, and the Transition of these Systems to the Stable State", *J. Inorg. Chem. Acad. Sci. USSR* **3** No. 4 (1958

136-50. (From *Zhur. Neorg. Khim.* 3 No. 4 (1958) 924-33.)

Included description of the principle of the catapult/piston-and-anvil device for quenching molten alloys, described more fully in [31] (QT: 6a), z down to 20 to 30 μm). Reported formation of austenite by diffusionless solidification of Fe-3 to 5 wt % C and formation of Fe_3C supersaturated with Fe.

152. I. V. SALLI, "Crystallization of Highly Supercooled Binary Alloys", Trudy 4-ogo (Chetvertogo) Soveshch. po Teorii Liteĭnykh Protsessov, Akad. Nauk SSSR, Inst. Mashinoved. 1958 (Moscow, 1960) pp. 69-75 (in Russian). See *Chem. Abs.* **55** (1961) 8254b.

Discussed phenomena of TSSE and eutectic alloy morphological change on solidification of alloys at high dT/dt.

153. I. V. SALLI and A. K. KUSHNEREVA, "Effect of High Cooling Rates on Structure Formation in Al-Ge and Ge-Sn Alloys", *Akad. Nauk Ukrain. SSR Metallofizika* **1970** No. 27, 189-94 (in Russian). See *Metals Abs.* **3** No. 11 (1970) 12-1221; *Chem. Abs.* **74** (1971) 5978n.

Reported and discussed TSSE to 7 at. % Ge in Al and formation of two new MCS phases in Al-Ge Alloys (see also [118]) by catapulting a drop of melt on to a rotating brass disc ($dT/dt \sim 10^6$ K sec^{-1}). Regular behaviour was reported for Ge-Sn eutectic alloy.

154. I. V. SALLI and L. P. LIMINA, "Extension of the Solidus into Subcritical Regions", *Izv. VUZ Tsvetnaya Met.* **8** No. 4 (1965) 117-22 (in Russian). See *Chem. Abs.* **64** (1966) 385b; *Metall. Abs.* **1** (1966) 170.

Concluded that when extended solid solutions (e.g. Ag-Cu Al-Zn at $dT/dt \sim 10^6$ K sec^{-1}) form in combination with metastable phases, extension of an equilibrium solidus will predict incorrectly the composition of metastable solid solutions.

155. I. V. SALLI and L. P. LIMINA, "Characteristics of Crystallization at High Cooling Rates", in *Growth and Imperfections of Metallic Crystals*, Ed. D. E. Ovsienko (Consultants Bureau, New York, 1968) pp. 251-4. (From Russian original (1966) pp. 316-20.)

Discussed the significance of results on TSSE in Ag-Cu, Al-Zn, Al-Mn and Cu-Pb solidified at $dT/dt \sim 10^6$ K sec^{-1} (QT: 3b.)

156. I. V. SALLI and I. S. MIROSHNICHENKO, "Some Features of the Crystallization of Alloys of the Eutectic Type of High Rates of Cooling", *Doklady Akad. Nauk SSSR* **132** (1960) English version pp. 557-9, Russian version pp. 1364-7.

Reported TSSE in *Al*-Mn, *Al*-Cr, *Ni*-C and *Co*-C and its absence in Al-Si, Pb-Sn and Bi-Sn alloys solidified at $dT/dt \sim 10^5$ K sec^{-1} (QT:6a).

157. R. STOERING and H. CONRAD, "Metastable Structures in Liquid Quenched and Vapor Quenched Ag-Cu Alloys", *Acta Metallurgica* **17** (1969) 933-48.

Reported XRD and TEM study of metastable solid Ag-Cu alloys quenched from both liquid (QT: 3e) and vapour phases. Segregation within Ag-rich metastable fcc solid solutions became stronger at higher substrate T in the range (−150 to +50°C) and for the Ag-50 at. % Cu alloy, with increasing T of annealing.

158. A. TONEJC and A. BONEFAČIĆ, "Enhanced Solubility of Fe in Al obtained by a Rapid Quenching Technique", *J. Appl. Phys.* **40** (1969) 419-20.

Reported TSSE to 4.4 at. % Fe in Al in foils (z < 15 μm) made by a two-piston technique (after QT : 7b, see [159]). Solid solutions with up to 3 at. % Fe were stable for at least 4 months at room temperature, but decomposed within 10 min at 300° C.

159. A. TONEJC and A. BONEFAČIĆ, "Al-Rich Metastable Al-Ti Solid Solutions", *Scripta Metall.* **3** (1969) 145-7.

Reported TSSE to 0.22 at. % Ti in Al in foils (z < 5 μm) made by method of [158] (after QT: 7b).

160. A. TONEJC and A. BONEFAČIĆ, "Metastable Solubility of W in Al", *Trans. Met. Soc. AIME* **245** (1969) 1664 only.

Reported TSSE to 0.95 at. % W in Al in foils (z < 5 μm) made by method of [158] (after QT: 7b).

161. A. TONEJC and A. BONEFAČIĆ, "X-ray and Metallographic Study of Rapidly Quenched Ag-Pb Alloys", *Fizika* **2** Suppl. 2 (1970) 32.1-32.5. Discussion 32.5.

Attempted to obtain TSSE of Pb in Ag by method of [158] (after QT: 7b), but retained only maximum equilibrium solid solubility, attributed to the intervention of an incipient liquid miscibility gap.

162. A. TONEJC and A. BONEFAČIĆ, "Volume Lattice Distortions for Binary Alloys of Al with Transition Metals Mn, Fe, Co and Ni", *Fizika* **2** (1970) 81-6.

Reported TSSE to 5.2 at. % Ni in Al by method of [159] and notes that such metastable solid solutions of Mn, Fe, Co and Ni in Al show a trend in lattice distortion with increasing atomic number in the opposite sense to their effect in Cu and Au as solvents.

163. N. I. VARICH, L. M. BUROV, K. YE. KOLESNICHENKO, and A. P. MAKSIMENKO, "Highly Supersaturated Al-V, Al-Mo and Al-W Solid Solutions Obtained at a High Rate of Cooling", *Phys. Metals. Metallog.* **15** No. 2 (1963) 111-3. (From *Fiz. Metal. Metalloved.* **15** (1963) 292-5.)

Reported TSSE to 1.20 wt. %V in Al-0.63 wt.% Mo in Al and 1.00 wt.% W in Al made by a catapult method (QT as 2a, $dT/dt \sim 5 \times 10^4$ K sec^{-1}), microhardness

measurements being used in addition to XRD. Decomposition of the solid solutions began within ½ h at 350 to 400° C for *Al*-V and at 400 to 450° C for *Al*-W. Variation of thermo-e.m.f. and paramagnetic susceptibility with composition indicated "homogeneous" metastable solid solubility limits 0.5 to 0.7 of the "inhomogeneous" limits indicated by XRD and microhardness.

164. N. I. VARICH and K. YE. KOLESNICHENKO, "The Effect of High Cooling Rate on the Structure and Properties of Al alloys", *Izv. VUZ Tsvetnaya Met.* **3** No. 4 (1960) 131-6 (in Russian). See *Chem. Abs.* **55** (1961) 1370c; *Metall. Abs.* **28** (1961) 715.

Reported TSSE in Al up to 6 wt % Cr and Al up to 10 wt % Mn alloys, as indicated by XRD and paramagnetic susceptibility, solidified at $dT/dt \sim 5 \times 10^4$ K sec^{-1} (QT: 2a), the solid solutions being uniform up to 1.8 wt % Cr and 5 wt % Mn. The Al-5.7 wt % Cr solid solution had a strength of 60 kg mm^{-2}. Metastable Al_4Mn and Al_4Cr began to form at higher Cr and Mn contents, Al_4Cr decomposing on annealing at 450 to 550° C.

165. N. I. VARICH and K. YE. KOLESNICHENKO, "The Effect of Fast Solidification Rates on the Structure and Properties of Thin Strips Obtained from Al Alloy Melts", Teplofiz. v Liteinom Proizv., Akad. Nauk Beloruss. SSR (Minsk, 1963) pp. 244-50 (in Russian). See *Metall. Abs.* **32** (1964-5) 149.

Reported TSSE to 2% Cr in Al and 6% Mn in Al, made by a catapult method (QT: 2a, $z = 100$ to 300 μm, $dT/dt \sim 5 \times 10^4$ K sec^{-1}). Limits of TSSE were based on metallography, hardness, magnetic susceptibility, resistivity and thermo-e.m.f. measurements as well as by XRD.

166. N. I. VARICH and B. N. LITVIN, "Study of Mg-Mn and Mg-Zr Alloys Prepared by Quenching from the melt", *Phys. Metals Metallog.* **16** No. 4 (1963) 29-32. (From *Fiz. Metals Metalloved.* **16** (1963) 526-9.)

Reported TSSE to 5.4 wt % Mn in Mg and 1.2 wt % Zr in Mg, made by a catapult method (QT: 2a, $z = 100$ to 300 μm, $dT/dt \sim 5 \times 10^4$ K sec^{-1}). These solid solutions decomposed between 250 and 300° C on annealing.

167. N. I. VARICH and R. B. LYUKEVICH, "Influence of Superheating on Structure and Phase Composition of Al-W alloys", *Russian Metallurgy* (*Metally*) **1970** No. 2, pp. 135-8. (From *Izv. Akad. Nauk SSSR Metally* **1970** No. 2, pp. 216-9.)

Reported that TSSE of W in Al, as indicated by microhardness, resistivity and XRD studies, increased with increasing melt superheat prior to quenching together with a fine dispersion of metastable Al_4W. (QT as 3a, b, brass cylinder substrate at 3000 rpm, $dT/dt \sim 10^6$ K sec^{-1}, $z = 50$ to 100 μm.)

168. N. I. VARICH and R. B. LYUKEVICH, "Phase Formation in Al-Cr Alloys Quenched from the Liquid State", *Russian Metallurgy* (*Metally*) **1970** No. 4, 58-60. (From *Izv. Akad. Nauk SSSR Metally* **1970** No. 4, 82-5.)

Reported that TSSE of Cr in Al increased with increasing melt superheat, at $dT/dt \sim 10^4$ K sec^{-1} (static Cu substrate, $z \sim 500$ μm) and $\sim 10^6$ K sec^{-1} (revolving brass cylinder substrate, $z \sim 50$ μm), together with a fine dispersion of metastable Al_4Cr.

169. N. I. VARICH, R. B. LYUKEVICH, L. F. KOLOMOYTSEVA, A. N. VARICH, and V. V. MASLOV, "Effect of Superheating the Melt on the Structure and Properties of Rapidly Cooled Al-Zr Alloys", *Phys. Metals Metallog.* **27** No. 2 (1969) 176-9. (From *Fiz. Metal. Metalloved.* **27** (1969) 361-4.)

Reported that TSSE of Zr in Al increased with increasing melt superheat prior to quenching (QT as for [167]), on the basis of XRD, microhardness and resistivity studies.

170. N. I. VARICH, R. B. LYUKEVICH, G. I. SCHERBAKOV, and L. F. KOLOMOYTSEVA, "Supersaturation of a Solid Solution after Superheating the Melt", *Izv. VUZ Tsvetnaya Met.* **12** No. 4 (1969) 116-9 (in Russian). See *Chem. Abs.* **72** (1970) 349112; *Metals Abs.* **3** No. 2 (1970) 11-0076.

Reported TSSE of Cr in Al and V in Al etc. solidified at $dT/dt \sim 10^6$ K sec^{-1} on a rotating brass cylinder and discussed the effect in relation to other published data.

171. N. I. VARICH and A. N. PETRUNINA, "Crystallization of Ni-Ta and Ni-Nb at Superhigh Cooling Rates", *Phys. Metals Metallog.* **31** No. 2 (1971) 239-40. (From *Fiz. Metal. Metalloved.* **31** (1971) 447-8.)

Reported TSSE to 19.5 at. % Ta in Ni and to 17.25 at. % Nb in Ni (QT as 3a, b rotating Cu cylinder substrate at 800 rpm, $z = 10$ to 30 μm, $dT/dt \sim 10^7$ to 10^8 K sec^{-1}) and decrease of grain size with increased alloy concentration in the solid solutions.

172. N. I. VARICH, A. N. PETRUNINA, and A. A. YAKUNIN, "Crystallization of Ni-Zr Alloys at High Cooling Rates", *Russian Metallurgy* (*Metally*) **1971** No. 5, pp. 84-5. (From *Izv. Akad. Nauk SSSR Metally*, **1971** No. 5, pp. 111-2.)

Reported XRD and microhardness evidence for TSSE up to 6.9 at. % Zr in Ni using a copper cylinder rotating at 8000 rpm as substrate ($dT/dt \sim 10^7$ to 10^8 K sec^{-1}, $z = 10$ to 30 μm.)

173. N. I. VARICH and T. I. SHEYKO, "Thermal Expansion of Al-Mo, Al-Zr Alloys Prepared at High Cooling Rates", *Phys. Metals Metallog.* **30** No. 2 (1970) 231-2. (From *Fiz. Metal. Metalloved.* **30** No. 2 (1970) 443-5.)

Reported variation with T (23 to 450° C) of thermal expansion coefficient derived from lattice parameter measurements for Al-Mo and Al-Zr extended solid solutions. (QT: 3a, $z = 90$ to 100 μm.)

174. N. I. VARICH and A. A. YAKUNIN, "The Solubility of Cd, Mg, Sb and Sn in Pb on Quenching the Alloys from the Liquid State", *Russian J. Phys. Chem.* **41** (1967) 437-40. (From *Zhur. Fiz. Khim.* **41** (1967) 844-8.)

Reported TSSE in Pb binary alloys up to 7 at.% Cd, 9.5 at.% Mg, 5.5 at.% Sb and 20 at.% Sn. (QT: 3a, using catapult and rotating brass cylinder substrate cooled with liquid N_2.)

175. N. I. VARICH and A. A. YAKUNIN, "Influence of the Rate of Cooling on the Formation of the Primary Structure in Sn-Sb Alloys", *Russian Metallurgy (Metally)*, **1968** No. 2, pp. 148-52. (From *Izv. Akad. Nauk SSSR Metally*, **1968** No. 2, pp. 229-34.)

Reported limit of TSSE increasing with increasing dT/dt (10^3 to 10^6 K sec^{-1}) up to 22 at.% Sb in Sn at 10^6 K sec^{-1}.

176. R. WANG, "Continuous Series of Metastable Hexagonal Close-Packed Solid Solutions in the Er-Zr system", *Appl. Phys. Letters* **17** (1970) 460-2.

Reported complete TSSE in cph Er-Zr alloys by splat cooling at $dT/dt \sim 10^7$ K sec^{-1} (QT: [26]), consistent with Hume-Rothery's Rules. See also [A48].

3.5.A. Metastable crystalline solid (MCS) intermediate phases

[See also refs. 16, 32, 38, 58-9, 78, 81-2, 93-5, 118, 126, 132, 151, 153, 164, 167-8, 229, 236, 250-2, 259-61, 267, 270, 272-3, 276, 279, 288, 294, 296, 321, 326-7, 329, 334, 338, 340-1, 343-5, 355, 364-5, 370-1, 382, 386, 388, 389a, 391, 399, 401, A9, A15, A26, A27, A31, A36, A37, A43, A47, A58, A65-6]

177. H. ABE, K. ITO, and T. SUZUKI, "Metastable fcc phase in Mg-Pb obtained by Rapid Cooling from the Melt", *Acta Metallurgica* **18** (1970) 991-4.

Reported formation and lattice parameters of a metastable Cu_3Au-I type ordered fcc phase in Mg-16 to 23 at.% Pb alloys (QT: 1a, $z \sim 5$ μm), consistent with Engel's empirical range of valency electron concentration per atom (2.25 to 3) for stability of the fcc structure. The phase decomposed into terminal Mg cph phase and Mg_2Pb on storage at room temperature.

178. H. ABE, K. ITO, and T. SUZUKI, "Metastable Phases in Mg-Sn Alloys obtained by Splat Cooling", *Trans. Jap. Inst. Metals* **11** (1970) 368-70.

Reported formation and lattice parameters of a metastable fcc phase in Mg-14 to 18 at.% Sn alloys (QT: 1a), analogous to that formed for Mg-Pb alloys, but disordered in this case. Another, more complex, MCS phase formed at > 33 at.% Sn.

179. J. ALTMANN and K. LÖHBERG, "Solidification of Intermetallic Compounds at High-Rate Cooling of Melts", *Fizika* **2** Suppl. 2 (1970) 5.1-5.5. Discussion 5.6.

Reported that a number of liquid alloys with the composition of congruently melting intermetallic compounds still formed the equilibrium compound on rapid solidification (QT: 1i, $z \sim 30$ μm, locally 5 μm, $dT/dt \sim 10^4$ to 10^6 K sec^{-1}). A number of eutectic alloys were refined in structure, but only some Te eutectic alloys formed AS phases.

180. T. R. ANANTHARAMAN, H-L LUO, and W. KLEMENT, "Non-equilibrium Structures in Au-Ge Alloys", *Trans. Met. Soc. AIME* **233** (1965) 2014-7.

Reported formation and lattice parameters of a metastable cph Hume-Rothery phase and a metastable complex tetragonal phase in Au-Ge alloys quenched from the melt. (QT: 3a.)

181. T. R. ANANTHARAMAN, H-L LUO, and W. KLEMENT, "Formation of New Intermediate Phases in Binary Eutectic Systems by Drastic Undercooling of the Melt", *Nature* **210** (1966) 1040-1.

Reported slight TSSE of Ge in both Ag and Au, formation of AS phases near Au-Si and Au-Ge eutectic compositions and formation and lattice parameters of six new MCS phases in Ag-Si and Ag-Ge, Au-Si and Au-Ge alloys reporting XRD evidence of stacking faults for four of them, and that two of them were superconductors (QT: [26]). Parallels were drawn between these MCS phases formed in eutectic systems and martensitic phases formed in eutectoid systems.

182. C. BORROMÉE-GAUTIER, B. C. GIESSEN, and N. J. GRANT, "Metastable Phases in the Pb-Sb and Pb-Bi Systems", *J. Chem. Phys.* **48** (1968) 1905-11.

Reported TSSE of Pb in Sb and Bi and formation and lattice parameters of several new MCS phases in Pb-Sb and Pb-Bi alloys including bcc Pb-Sb, primitive cubic Pb-Sb and complex Pb-Bi phases (QT: gun technique on to copper at −190° C).

183. C. C. CHAO, H-L. LUO, and P. DUWEZ, "CsCl-type Compounds in Binary Alloys of Rare-Earth Metals with Au and Ag", *J. Appl. Phys.* **34** (1963) 1971-3.

Reported lattice parameters of a number of equiatomic CsCl-type binary compounds of rare-earths with Au and Ag, some prepared by quenching the melt. (QT: 1a), correlating the lattice parameter with the rare-earth trivalent ionic radii. See also [184].

184. C. C. CHAO, H-L. LUO, and P. DUWEZ, "CsCl-type Compounds in Binary Alloys of Rare-Earth Metals with Zn and Cu", *J. Appl. Phys.* **35** (1964) 257-8.

Reported lattice parameters of a number of equiatomic CsCl-type binary compounds of rare-earths with Zn and Cu, one of which (CuSm) was formed

only by rapid cooling of the melt. (QT: [26].) See also [183].

185. P. DUWEZ, R. H. WILLENS, and W. KLEMENT, "Metastable Electron Compound in Ag-Ge Alloys", *J. Appl. Phys.* **31** (1960) 1137 only.

Reported formation and lattice parameters of a new cph Hume-Rothery phase in a nearly eutectic Ag-25.7 at.% Ge alloy quenched from the melt. (QT: 1a and/or 3a.)

186. V. A. FILONENKO, "The Ge-Al Eutectic", *Russian J. Phys. Chem.* **44** (1970) 883-4. (From *Zhur. Fiz. Khim.* **44** (1970) 1575-7.)

Reported identification by metallography and XRD of an MCS Al_2Ge phase of microhardness 530 ± 10 kg mm^{-2} in the Ge-47 at.% Al eutectic alloy quenched from the melt ($dT/dt > 10^5$ K sec^{-1}).

187. B. C. GIESSEN, "A Metastable γ-Brass Phase in the Au-Sn System and a Note on Non-Equilibrium Hume-Rothery Phases", *Z. Metallk.* **59** (1968) 805-9.

Reported formation, lattice parameter and composition of a non-equilibrium γ-brass phase in Au-29 at.% Sn alloy quenched from the melt ($dT/dt \sim 10^7$ to 10^8 K sec^{-1}). In addition formation of a microcrystalline phase of another MCS phase and extension of the equilibrium ζ phase field was reported for alloys in the composition range 17 to 45 at.% Sn.

188. B. C. GIESSEN, R. H. KANE, and N. J. GRANT, "A Metastable Intermediate Phase in the System In-InSb", *Nature* **207** (1965) 854-5.

Reported formation, composition (In_3Sb_2) and lattice parameters of a new simple hexagonal phase in In-InSb (eutectic) alloys and indications of a further metastable phase at alloy composition Sb-25 at.% In, on rapid cooling of the melt ($dT/dt \sim 10^6$ to 10^7 K sec^{-1}) by a gun technique.

189. B. C. GIESSEN, M. MORRIS, and N. J. GRANT, "Metastable In-Bi Phases Produced by Rapid Quenching", *Trans. Met. Soc. AIME* **239** (1967) 883-9.

Reported formation, composition and lattice parameters of five new MCS phases and one new equilibrium phase of the In-Bi system. (QT: 1a, Ag and Cu substrates at −190°C.)

190. B. C. GIESSEN and R. RAY, "The Metastable Phase $(Al_{0.5}Nb_{0.5})Ni_3$", *J. Less Common Metals* **23** (1971) 95-7.

Reported formation and lattice parameters of an extended Ni-base terminal solid solution, an extended intermediate solid solution (possibly of AlNi) and a new MCS phase isostructural with $(Al_{0.5}Ta_{0.5})Ni_3$ in the alloy Ni-12.5 at.% Nb-12.5 at.% Al. (QT: 1h.)

191. B. C. GIESSEN and D. SZYMANSKI, "A Metastable Phase $TiCu_3$(m)", *J. Appl. Cryst.* **4** (1971) 257-9.

Reported formation and lattice parameters of a new metastable orthorhombic phase $TiCu_3$(m), related to $ZrAu_3$, and decomposing within 1 h at 500°C, in Cu-20, 22 and 25 at.% Ti alloys and TSSE to 17 ± 2 at.% Ti in Cu. (QT: 1h.)

192. B. C. GIESSEN, U. WOLFF, and N. J. GRANT, "The Metastable System Ga-Al and the Atomic Volume of Twelvefold Coordinated Ga", *J. Appl. Cryst.* **1** (1968) 30-5.

Reported TSSE to 8 at.% Al in Ga and to 65 at.% Ga in Al and formation of two new MCS phases at 12 to 14 at.% and 17.5 to 35 at.%, respectively of Al in Ga. Extrapolation of lattice parameter data yielded the atomic volume of twelvefold coordinated Ga. (QT: gun type, Cu substrate at −190°C, $z < 1$ μm, $dT/dt \sim 10^7$ to 10^9 K sec^{-1}.)

193. B. C. GIESSEN, U. WOLFF, and N. J. GRANT, "Metastable Simple Cubic Phases Based on Sb and Bi", *Trans. Met. Soc. AIME* **242** (1968) 597-602.

Reported formation, composition and lattice parameters of metastable simple cubic phases in Sb-Au, Sb-Pd, Sb-Ni and Au-Bi alloys, and also a microcrystalline and a distorted simple cubic phase in the latter case. (QT: 1h, $z = 1$ to 5 μm, $dT/dt \sim 10^7$ to 10^8 K sec^{-1}.) Complex annealing behaviour was reported for certain of the Au-Bi phases.

194. A. K. JENA, B. C. GIESSEN, M. B. BEVER, and N. J. GRANT, "The Metastability of Au-Sb Phases Prepared by Splat-Cooling", *Acta Metallurgica* **16** (1968) 1047-51.

Reported solution calorimetric measurements of heats of formation of cph ζ Au-15 at.% Sb and simple cubic π Au-76.6 at.% Sb metastable phases made by splat cooling. (QT: 1a.) Calculations of free energies of formation by the Neumann-Kopp rule predict that supercoolings of at least 150 and 200 K were required to form these phases. See also [213].

195. C. B. JORDAN, "Metastable Simple Cubic Structure in the In-Sb System", *J. Chem. Phys.* **39** (1963) 1613-4.

Reported formation and lattice parameters of a metastable simple cubic phase in Sb-30 and 40 wt % In alloys. (QT: [26].)

196. R. H. KANE, B. C. GIESSEN, and N. J. GRANT, "New Metastable Phases in Binary Tin Alloy Systems", *Acta Metallurgica* **14** (1966) 605-9.

Reported formation, composition and lattice parameters of metastable simple hexagonal phases in a number of Sn alloys at valence electron concentration of 3.4 to 3.9 per atom. The phases decomposed at room temperature and below. (QT: 1a, $dT/dt \sim 10^6$ K sec^{-1}, Ag or Cu substrate at −190°C.)

197. W. KLEMENT, "Lattice parameters of the Meta-

stable Close-Packed Structures in Ag-Ge Alloys", *J. Inst. Metals* **90** (1961-2) 27-30.

Reported lattice parameters as a function of composition for the extended terminal fcc and metastable intermediate cph phases formed in *Ag*-Ge alloys. (QT: 3a, $z = 15 \pm 5$ μm.) Some observations on the effect of annealing and of cold-working for the cph Ag-25.9 at. % Ge phase.

98. W. KLEMENT, "Cph Structures in Bi-Pb Alloys and the Polymorphism of Pb at High Pressures", *J. Chem. Phys.* **38** (1963) 298-9.

Reported lattice parameters as a function of composition for extended solid solutions of the equilibrium cph phase forming in Pb-27.0 to 32.0 at. % Bi alloys. (QT: 3a.) Extrapolation of this data together with activity allowed free energy of cph Pb to be predicted relative to the fcc form, suggesting that the cph form should be stable at pressures > 0.16 Mbar.

199. W. KLEMENT, "Metastable Close-Packed Structures in Ag-Rich Binary Alloys with Sn, Sb and Si", *Trans. Met. Soc. AIME* **233** (1965) 1182-3.

Reported lattice parameters as a function of composition for slightly extended terminal fcc solid solutions of Sb and Sn in Ag, coexisting with metastable cph phases also found in Ag-10 to 25 at. % Si alloys. (QT: 3a.)

200. E. KRAINER and J. ROBITSCH, "Detection of Cubic WC in Cemented Carbides Processed by Spark Erosion and in Pure Fused Tungsten Carbides", *Planseeber Pulvermet.* **15** No. 1 (1967) 46-56 (in German). See *Chem. Abs.* **68** (1968) 24291a.

Reported XRD evidence for formation of the high-temperature form of WC in spark-eroded regions of cemented carbides and pure fused tungsten carbides. See also [201, 386].

201. E. KRAINER and J. ROBITSCH, "Phase Transformation in Metal Surfaces during Spark Erosion and other High Energy Treatments", *Metall.* **25** (1971) 1361-4 (in German). See *Metals Abs.* **5** No. 7 (1972) 11-0495.

Reported XRD evidence for formation of high-temperature forms of Co and WC by spark-erosion. See also [95, 116, 200, 386].

202. H-L LUO and W. KLEMENT, "Metastable Simple Cubic Structures in Au-Te and Ag-Te Alloys", *J. Chem. Phys.* **36** (1962) 1870-4.

Reported formation and lattice parameters as a function of composition of single-phase metastable simple cubic structures in Te-15 to 40 at. % Au and Te-20 to 30 at. % Ag alloys. (QT: 3a, $z < 5$ μm), the Te-37.5 at. % Au showing most stability on annealing.

203. H-L LUO, W. KLEMENT, and T. R. ANANTHARAMAN, "Effects of Liquid Quenching on the Constitution and Structure of Ag-Si and Au-Si Alloys", *Trans. Indian Inst. Metals* **18** (1965) 214-8.

Reported formation and lattice parameters of a metastable cph Hume-Rothery phase in Ag-Si alloys and of two complex fcc phases in Au-Si alloys. (QT: 3a, $dT/dt \sim 10^6$ to 10^8 K sec^{-1}.) Metastable constitution was discussed in relation to phase diagrams of dT/dt against composition.

204. T. B. MASSALSKI, L. F. VASSAMILLET, and Y. BIENVENU, "Splat Cooling of Zn-rich Cu and Ag Alloys", Abstract of paper presented at Annual Pitsburgh Diffraction Conference, November 1970. See *Phys. Abs.* **74** (1971) 21363 and *Acta Met.* (1973).

Reported possible formation of metastable "m" phase, in addition to stable ϵ and γ, decomposing to ϵ plus γ on annealing.

205. M. MOSS, D. L. SMITH, and R. A. LEFEVER, "Metastable Phases and Superconductors produced by Plasma-Jet Spraying", *Appl. Phys. Letters* **5** (1964) 120-1.

Reported use of plasma jet spraying (QT: 1b) on to a cooled Cu plate to produce TSSE in Ag-40 at. % Cu, the metastable cph phase in Ag-26 at. % Ge and a homogeneous superconducting phase in Mo-40 at. % Ru.

206. P. PREDECKI, B. C. GIESSEN, and N. J. GRANT, "New Metastable Alloy Phases of Au, Ag and Al", *Trans. Met. Soc. AIME* **233** (1965) 1438-9.

Reported formation and lattice parameters of a metastable cph phase in Au-13 to 15 at. % Sb and Au-21 at. % Ge, a probably cubic metastable phase in Au-20 to 21 at. % Si, an AS phase in Au-75 at. % Pb and Ag ~ 75 at. % Pb and a complex MCS phase in Al-30 at. % Ge. (QT: 1d.) The cph Au-Sb phase decomposed after several months at room temperature or after $\frac{1}{2}$ h at 200°C.

207. P. RAMACHANDRARAO and T. R. ANANTHARAMAN, "New Metastable Phases in Ag-Ge and Au-Ge Alloys Quenched from the Melt", *Trans. Met. Soc. AIME* **245** (1969) 886-7.

Reported formation of a metastable tetragonal phase in addition to the expected cph metastable phase in Ag-21 at. % Ge and of two new tetragonal phases as well as the expected metastable cph and tetragonal phases in Au-27 at. % Ge, solidified by a gun technique ($dT/dt \sim 10^6$ to 10^8 K sec^{-1}) and by water quenching ($dT/dt \sim 10^5$ K sec^{-1}).

208. P. RAMACHANDRARAO and T. R. ANANTHARAMAN, "Influence of Cooling Rate on the Crystallization of a Au-Ge Alloy", *Trans. Indian Inst. Metals* **23** No. 2 (1970) 58-63.

Reported the effect of process variables on the structure of splat-cooled Au-27 at. % Ge eutectic alloy. (QT: 1j.) Three new tetragonal phases were reported to occur on quenching from different *T*.

209. P. RAMACHANDRARAO, C. SURYANARAYANA, and T. R. ANANTHARAMAN, "On the Origin of Metastable Intermediate Phases in Splat-Cooled Binary Alloys", *Metall. Trans.* **2** (1971) 617-9.

Showed that the composition range of occurrence of several intermediate phases correlated well with that of inflections in excess partial entropy of the liquid alloy plotted as a function of composition.

210. R. C. RUHL, B. C. GIESSEN, M. COHEN, and N. J. GRANT, "Metastable Cph Phases in Ni-Rich Ni-Nb and Ni-Ta Alloys", *J. Less Common Metals* **13** (1967) 611-8.

Reported TSSE of Nb and Ta in Ni, extension of the $NbNi_3$ solid solution in Ni-Nb alloys and formation of metastable cph and microcrystalline phases in Ni-Nb and Ni-Ta alloys. (QT: 1h.) The formation of the cph phases was accounted for by valence electron concentration estimates.

211. R. C. RUHL, B. C. GIESSEN, M. COHEN, and N. J. GRANT, "Metastable Bcc Phases in the V-Ni and Ni-In Systems", *Mater. Sci. Eng.* **2** (1968) 314-9.

Reported that a metastable bcc or microcrystalline phase replaced the equilibrium σ-phase in V-33 to 53 at. % Ni alloys and a similar bcc phase occurred in Ni-16 to 25 at. % In alloys. (QT: 1h.)

212. P. T. SARJEANT and R. ROY, "Splat Quenched Melts in the MgO-Al_2O_3 System", *J. Appl. Phys.* **38** (1967) 4540-2.

Reported a marked extension of the metastable spinel structure crystalline solution in MgO-Al_2O_3 towards the high MgO composition. (QT: 1f.)

213. H. P. SINGH, C. SURYANARAYANA, S. MISRA, and T. R. ANANTHARAMAN, "Energetics of the Non-equilibrium Phases in the System Pb-Bi", *Z. Metallk.* **62** (1971) 52-5.

Reported solution calorimetric measurements of the heats of formation at 80 K of the metastable X (Bi-44 at. % Pb) and Y (Bi-11 at. % Pb) phases obtained by liquisol quenching (QT: 1j), and also of the ϵ (Pb-34 at. % Bi) phase. Calculated free energies of formation indicated that supercoolings of at least 20 and 35 K would be required to form the X and Y phases. See also [194].

214. P. K. SRIVASTAVA, B. C. GIESSEN, and N. J. GRANT, "New Metastable Electron Phases in Binary B-Metal Alloys", *Acta Metallurgica* **16** (1968) 1199-208.

Reported metastable effects in 19 binary B-metal systems on splat cooling to $-190°C$ (QT: 1a), including new fcc phases in Ag-In, Zn-Ga and Cd-Sn, marked solid solubility extension of equilibrium intermediate fcc α in Cd-In, a new simple hexagonal phase in Cd-Bi and new phases in Ga-Zn, -Cu, -Ni and Bi. Factors governing the formation of these fcc and hexagonal phases were discussed.

215. C. SURYANARAYANA, "Constitution, Structure and Energetics of Splat-Cooled Alloys", *Scripta Metall.* **5** (1971) 337-40.

Reported effect of splat cooling on Al-Ge [216-9], Al-Si, Au-Si, Cu-Zn [220, 401] and Pb-Bi [213] alloys and determination of crystal structures and heats of formation of non-equilibrium intermediate phases formed. Summary of Ph.D. Thesis, Banaras, 1970. See also [209].

216. C. SURYANARAYANA and T. R. ANANTHARAMAN, "Formation of an Intermediate Phase in the Al-Ge System", *Current Science (India)* **37** (1968) 631-3.

Reported formation and lattice parameters of a new metastable tetragonal phase (120 atoms per unit cell) in splat-cooled Al-30 at. % Ge eutectic alloy. (QT: 1a.)

217. C. SURYANARAYANA and T. R. ANANTHARAMAN, "Impact of Quenching from Melt on Equi-atomic Al-Ge Alloy", *Current Science (India)* **39** (1970) 123-5.

Reported formation and lattice parameters of a new metastable tetragonal phase (208 atoms per unit cell) in Al-50 at. % Ge alloy. (QT: 1a.)

218. C. SURYANARAYANA and T. R. ANANTHARAMAN, "Solidification of Al-Ge Alloys at High Cooling Rates", *J. Mater. Sci.* **5** (1970) 992-1004.

Reported effect of dT/dt ($\sim 10^3$ to 10^7 K sec^{-1}) on the constitution of Al-Ge alloys quenched from the melt (QT: water quenching and 1j), as giving TSSE up to 7.2 at. % Ge in Al and two non-equilibrium tetragonal intermediate phases with large unit cells (see [216, 217]).

219. C. SURYANARAYANA and T. R. ANANTHARAMAN, "Metallography of Rapidly Solidified Al-Ge Alloys", *Metallography* **4** (1971) 79-82.

Reported metallographic identification of a metastable intermediate phase formed by splat-cooling Al-33.3 and 40 at. % Ge alloys by a gun technique. See also [A45].

220. C. SURYANARAYANA and T. R. ANANTHARAMAN, "Formation of Hexagonal Phases in α-β Brasses", *Metall. Trans.* **2** (1971) 3237 only.

Reported formation and lattice parameters of a new metastable hexagonal phase in Cu-38 to 42 wt % Zn alloys rapidly quenched from the melt. See also [401].

221. C. C. TSUEI and P. DUWEZ, "Simple Cubic and Amorphous Phases in Te-Base Alloys with Cu, Ag, and Au", Report CALT-221-33 (June 1967). Abstract in *Nucl. Sci. Abs.* **21** (1967) 36927.

Reported formation of metastable phases and the variation of their lattice parameters with composition for pseudo-binary alloys involving two of $Te_{70}Cu_{30}$, $Te_{70}Ag_{30}$ and $Te_{70}Au_{30}$, quenched from the melt.

222. D. WEAIRE and A. R. WILLIAMS, "On the Axial Ratios of Simple Hexagonal Alloys of Sn", *Phil. Mag.* **19** (1969) 1105-9.

Explained by the Ewald Energy criterion the observation that simple hexagonal phases, formed at equilibrium or by splat cooling, have axial ratios in the range 0.92 to 0.95.

3.5.B. Amorphous solid (AS) and microcrystalline solid phases

[See also refs. 8, 10-11, 18, 25, 27, 78, 104, 132, 179, 181, 187, 193, 206, 210-11, 265, 288-9, 299, 306-19, 323, 331-3, 335-9, 342, 350, 351, 362, 372, 380, 385a, 389, 395, 396, 400, 401a, A6-8, A11, A17-19, A28, A32, A33, A35, A38, A41, A42, A46, A53]

223. B. G. BAGLEY, H. S. CHEN, and D. TURNBULL, "Characterization of Amorphous Alloy Films", *Mater. Res. Bull.* **3** (1968) 159-68.

Discussed the problem of distinguishing in terms of structure and behaviour between the microcrystallite and continuous random models for AS alloy films with particular reference to splat-cooled Au-18 to 25 at. % Si and Au-13.6 at. % Ge-9.4 at. % Si alloys and also Ni-P alloys deposited by other techniques.

224. C. H. BENNETT, D. E. POLK, and D. TURNBULL, "Role of Composition in Metallic Glass Formation", *Acta Metallurgica* **19** (1971) 1295-8.

Explained the frequent occurrence of AS phases in alloys such as *Pd*-Si, *Au*-Si or *Au*-Ge-Si of a noble or transition metal A with 20 to 25 at. % metalloid element B, in terms of filling by B of holes in a Bernal dense random packed structure of A atoms.

225. V. BORTOLANI, M. CORCHIA, and F. NIZZOLI, "Relation between X-ray Diffraction and the Structure of Metallic Amorphous Alloys", *Phys. Letters* **33A** (1970) 315-6.

Reported that the XRD spectra of AS Au-30 at. % Si and Pd-20 at. % Si made by quenching the melt can be interpreted satisfactorily on the basis of a structural model appropriate for *liquid* binary alloys.

226. R. W. CAHN, "Criteria for Formation of Amorphous Phases", *Fizika* **2** Suppl. 2 (1970) 25.1-25.14.

Discussed various criteria, both structural and kinetic, accounting for or predicting conditions for glass formation in metallic alloys made by splat cooling, vapour quenching etc. as well as in more conventional oxide and chalcogenide glasses.

227. G. S. CARGILL, "Dense Random Packing of Hard Spheres as a Structural Model for Noncrystalline Metallic Solids", *J. Appl. Phys.* **41** (1970) 2248-50.

On the basis of XRD evidence for structural similarity between AS metallic alloys produced by such diverse means as splat cooling, vapour quenching and electrodeposition, showed that the derived pair distribution function of electrodeposited AS Ni-24 at. % P was in good agreement with that measured for dense random packing of hard spheres.

228. H. S. CHEN and D. TURNBULL, "Thermal Evidence of a Glass Transition in a Au-Si-Ge Alloy", *Appl. Phys. Letters* **10** (1967) 284-6.

Reported a peak in the specific heat-temperature curve of AS Au-13 at. % Ge -9.45 at. % Si made by splat cooling, at 295 K, just below the *T* at which crystallization intervenes to prevent further measurements. These specific heat values for the AS phase above 295 K fell on a reasonable extrapolation of the high-temperature specific heat data for the liquid alloy and thus were considered to be evidence for a glass to liquid transition in this case.

229. H. S. CHEN and D. TURNBULL, "Thermal Properties of a Au-Si Binary Alloy near the Eutectic Composition", *J. Appl. Phys.* **38** (1967) 3646-50.

Reported specific heat measurements for Au-18.6 at. % Si in MCS, AS and liquid forms as a function of *T*. The deep-lying eutectic of this system was attributed to the contrast between the tendency of unlike atoms to associate in the metallic state and that for phase separation in the solid state to allow highly stable covalent crystalline Si to form. (QT: 1a, ceramic crucible and Ta or Ag substrate at liquid nitrogen *T*.)

230. H. S. CHEN and D. TURNBULL, "Evidence of a Glass-Liquid Transition in a Au-Ge-Si Alloy", *J. Chem. Phys.* **48** (1968) 2560-71.

Reported thermal, resistivity and viscosity measurements as a function of *T* for AS *Au*-Ge-Si alloys made by splat cooling. (QT: 1a, as [229].) The specific heat peak reported in [228] was shown to be repeatable on a given sample and the apparent glass transition *T* increased by 1 to 3 K by increasing the heating rate $\times$ 16.

231. H. S. CHEN and D. TURNBULL, "Formation, Stability and Structure of Pd-Si Based Alloy Glasses", *Acta Metallurgica* **17** (1969) 1021-31.

Reported thermal evidence for the glass transition in AS *Pd*-Si alloys with and without Au, Ag or Cu ternary additions (QT: 1a, as [229], replacing stainless steel tube shock wave guide with ceramic one). AS phases were formed in thicknesses up to 1 mm or more ($dT/dt \sim 10^2$ K sec^{-1}) in certain alloys and could be heated as high as 40 K above the glass transition *T* without rapid crystallization. Electrical resistivity was measured and annealing behaviour described.

232. H. S. CHEN and D. TURNBULL, "Formation and Stability of Amorphous Alloys of Au-Ge-Si", *Acta Metallurgica* **18** (1970) 261-3.

Reported that increase of Au content in AS *Au*-Ge-Si alloys (QT: 1a, as [229]), gave a slight decrease of

glass transition temperature T_g (although the reduced T_g was nearly constant) and increased resistance to crystallization on annealing.

233. M. H. COHEN and D. TURNBULL, "Composition Requirements for Glass Formation in Metallic and Ionic Systems", *Nature* **189** (1961) 131-2.

Argued that the formation of an AS phase in splat-cooled Au-25 at. % Si [239] was a consequence of the low reduced melting T of this eutectic alloy, increasing the tendency for glass formation on rapid cooling. Once formed, the correspondingly increased stability of this AS phase compared with vapour-quenched AS alloy films, was as expected.

234. K. DAS GUPTA, "Soft X-ray Emission Spectra of Amorphous Pd-Si Alloy", *Appl. Phys. Letters* **6** (1965) 104-6.

Reported study of L_3 valence band spectra of Pd in AS Pd-20 at. % Si made by splat cooling and related this to the Pd spectra of pure Pd, Pd_2Si, crystalline Pd-20 at. % Si and Pd-H alloy.

235. P. DUWEZ, R. H. WILLENS, and R. C. CREWDSON, "Amorphous Phase in Pd-Si Alloys", *J. Appl. Phys.* **36** (1965) 2267-9.

Reported identification by XRD and TEM of an AS phase in Pd-15 to 23 at. % Si (QT: 6b, and gun [26]), stable for at least a month at 250°C. Heating rates > 20°C min^{-1} gave rapid crystallization at 400°C, and AS Pd-17 at. % Si had a resistivity at room temperature of 2.6 × that at equilibrium.

236. V. A. FILONENKO, "The Structure of the Au-Si Eutectic Mixture in the Liquid and Solid States", *Russian J. Phys. Chem.* **43** (1969) 874-6. (From *Zhur. Fiz. Khim.* **43** (1969) 1573-4.)

Related formation in Au-20 at. % Si eutectic alloy with increasing melt superheat of finely dispersed Au-Si eutectic, MCS Au_4Si and an AS phase respectively, to layer-ordering, Au_4Si ordering and total disorder in the liquid state.

237. F. GALASSO, R. VASLET, and J. PINTO, "Formation of Amorphous Boron from the Melt by Rapid Cooling", *Appl. Phys. Letters* **8** (1966) 331-2.

Reported identification by selected area diffraction of AS boron by quenching the melt. (QT: 6c.)

238. F. GALASSO, R. VASLET, and J. PINTO, "Amorphous Whiskers of a Co-Au Alloy", *Nature* **212** (1966) 176-7.

Reported TSSE of Co in Au formation of whiskers of an AS phase in Co-25 at. % Au quenched from the melt. (QT: 6c.)

239. W. KLEMENT, R. H. WILLENS, and P. DUWEZ, "Non-Crystalline Structure in Solidified Au-Si Alloys", *Nature* **187** (1960) 869-79.

Reported XRD evidence for formation of an AS phase in Au-25 at. % Si quenched from the melt (QT: 1a or 3a, $z \sim 10$ μm) decomposing into complex MCS phases within 24 h at room temperature.

240. D. LESUEUR, "Amorphisation of a Pd-Si Alloy under Irradiation", *Compt. Rend. Acad. Sci. Paris* **266B** (1968) 1038-41 (in French). See *Metals Abs.* **1** No. 11 (1968) 16-0344.

Reported the effect of irradiation by U_{235} fission products on as-quenched AS Pd-20 at. % Si made by quenching the melt (QT: 6b or 7b), and on the same material after annealing for 40 h at 800°C. The resistivity at 77 or 300 K of annealed samples increased.

241. D. LESUEUR, "Amorphisation of a Pd-Si Alloy by Irradiation with Fission Products", *Fizika* **2** Suppl. 2 (1970) 13.1-13.8.

Reported re-amorphization by fast neutrons or fission fragments of Pd-20 at. % Si which had been crystallized at 800°C for 40 h after original preparation in AS form by quenching the melt. (QT: 6b or 7b.)

242. S. C. H. LIN and P. DUWEZ, "Structure of an Amorphous Fe-P-C Alloy", *Phys. Stat. Sol.* **34** (1969) 469-74.

Reported that the XRD spectrum from AS Fe-13 at. % C quenched by a piston-and-anvil method ($z \sim 50$ μm) was consistent with a model structure of randomized bcc Fe.

243. H. L. LUO and P. DUWEZ, "Metastable Amorphous Phases in Te-Base Alloys", *Appl. Phys. Letters* **2** (1963) 21 only.

Reported formation of AS phases in Te-10 to 30 at. % Ga or In and in Te-10 to 25 at. % Ge alloys quenched from the melt.

244. P. L. MAITREPIERRE, "Structure of Amorphous Ni-Pd-P and Fe-Pd-P Alloys", *J. Appl. Phys.* **40** (1969) 4826-34.

Reported identification of AS (Ni or Fe, Pd)-15 to 20 at. % P containing 13 to 73 at. % Ni or 13 to 44 at. % Fe made by piston-and-anvil quenching of the melt ($z \sim 40$ μm). XRD spectra and electrical and magnetic properties were consistent with a structural model based on Pd_3P crystallites.

245. D. E. POLK, "Structural Model for Amorphous Metallic Alloys", *Scripta Metall.* **4** (1970) 117-22.

Discussed application to AS metallic alloys such as *Pd*-Si and *Fe*-P-C quenched from the melt of a metallic-based Bernal dense random packing model, with larger holes filled by the metalloid atoms.

246. P. RAMACHANDRARAO, P. K. GARG, and T. R. ANANTHARAMAN, "Rapid Quenching of Liquid Pb-Sb Alloys", *Indian J. Technol.* **8** (1970) 263-5.

Reported slight TSSE and formation of an AS phase in Pb up to 50 at. % Sb quenched from the melt. (QT: 1a.)

247. R. RAY, B. C. GIESSEN, and N. J. GRANT, "New Non-Crystalline Phases in Splat-Cooled Transition Metal Alloys", *Scripta Metall.* **2** (1968) 357-9.

Reported formation of microcrystalline phases (crystal diameter ~ 16 Å) in *Zr*-Ni, *Zr*-Pd, *Zr*-Cu, *Zr*-Co and *Cu*-Ti alloys quenched from the melt. (QT: 1h.)

248. R. C. RUHL, B. C. GIESSEN, M. COHEN, and N. J. GRANT, "New Microcrystalline Phases in the Nb-Ni and Ta-Ni Systems", *Acta Metallurgica* **15** (1967) 1693-702.

Reported formation of microcrystalline phases (crystal diameter ~ 16 Å) in Nb-Ni and *Ni*-Ta alloys quenched from the melt. (QT: 1h, z up to 25 μm, $dT/dt \sim 10^5$ to 10 K sec^{-1}.) The phases were stable for at least 1 h at 600°C, decomposing readily at higher T involving formation of a crystalline transition phase for Nb-Ni.

249. P. T. SARJEANT, "New Experimental and Theoretical Approaches to the Glassy State", *Dissert. Abs.* **29** No. 3 (1968). Abstract only.

Reported solid solubility extension and formation of AS phases in unary and binary oxides quenched from the melt.

250. P. T. SARJEANT and R. ROY, "New Glassy and Polymorphic Oxide Phases Using Rapid Quenching Techniques", *J. Amer. Ceram. Soc.* **50** (1967) 500-3.

Reported formation of new pure oxide glasses (V_2O_5, TeO_2, MoO_3 and WO_3), new MCS phases in WO_3 and Ta_2O: and of γ-spinels in Al_2O_3, quenched from the melt. (QT: 1f.)

251. P. T. SARJEANT and R. ROY, "A New Approach to the Prediction of Glass formation", *Mater. Res. Bull.* **3** (1968) 265-80.

Used the simplest possible kinetic equations to relate dT/dt for glass formation and viscosity to correctly predict occurrence of glass formation in some SiO_2- and TiO_2-based mixtures and its non-occurrence in MgO-Al_2O_3 NaCl, Pb and water, all cooled at $\sim 10^6$ K sec^{-1}. This prediction was based on an estimated critical dT/dt of 1.2×10^9 K sec^{-1} for glass formation in NaCl.

252. P. T. SARJEANT and R. ROY, "Experimental Data on Formation of New Non-Crystalline Solid (NCS) Phases", in *Reactivity of Solids*, Ed. J. W. Mitchell, R. C. De Vries, R. W. Roberts and P. Cannon (Wiley, New York 1969) pp. 725-32. Discussion p. 733.

Reported the application of [251] to AS or MCS phase formation in binary oxide systems, particularly rare earth oxide-alumina and MgO-SiO_2 systems, quenched from the melt (including QT: 1f.)

253. P. T. SARJEANT and R. ROY, "Ti^{4+} Co-ordination in Glasses in RO-TiO_2 Systems", *J. Amer. Ceram. Soc.* **52** (1969) 57-8.

Interpreted formation of AS phases in BaO-, CaO-, SrO-TiO_2 mixtures (but not in MgO-TiO_2) by quenching the melt (QT: 1f) in terms of the general rule that a cation radius difference >0.5 Å is needed for glass formation in binary oxide melts containing no glass-former.

254. A. K. SINHA and P. DUWEZ, "Radial Distribution Function of Amorphous Ni-Pt-P Alloys", *J. Phys. Chem. Solids* **32** (1971) 267-77. From Report CALT-822-21, January 1971.

Reported XRD spectra for AS (Ni_xPt_{100-x})-25 at.% P with $20 < x < 60$ made by quenching the melt. (QT: piston-and-anvil, $dT/dt \sim 10^6$ K sec^{-1}.) There was no shoulder on the high angle side of the second peak of the interference function, indicating a higher degree of disorder than for previously reported AS phases.

255. T. TAKAMORI, R. ROY, and G. J. MCCARTHY, Structure of Chalcogenide Glasses as a Function of Mechanism and Rate of Quenching", *Amer. Ceram. Soc. Bull.* **49** (1970) 424. Abstract only.

Reported characterization of AS phases in Te-Ge, As-Ge-Te, As-Se-Te and As-Se-Te-I systems made by splat cooling, water quenching, flash evaporation or sputtering.

256. T. TAKAMORI, R. ROY, and G. J. MCCARTHY, "Structure of Memory-Switching Glasses I. Crystallization Temperature and its Control in Ge-Te Glasses", *Mater. Res. Bull.* **5** (1970) 529-40.

Reported crystallization temperature T_c and glass transition temperatures T_g as a function of composition for Te-10 to 25 and 15 to 20 at.% Ge glasses made by splat-cooling and water quenching respectively. While T_g increased linearly from ~110 to 150°C with increasing Ge content, T_c passed through a maximum at 220°C near the eutectic composition consistent with its particular susceptibility to glass formation.

257. D. TURNBULL, "Under What Conditions can a Glass be Formed?", *Contemp. Phys.* **10** (1969) 473-88.

Discussed glass formation in terms of kinetic predictions of the condition for bypassing crystallization, on the grounds that glass formers are known for all classes of material according to bond type, although special methods, such as splat cooling, are required for metallic glasses, such as *Au*-Si, and *Pd*-Si, to form.

258. C. N. J. WAGNER, "Structure of Amorphous Thin Films", *J. Vacuum Sci. and Tech.* **6** (1969) 650-7.

Interpreted XRD and electron diffraction spectra of metallic AS phases, including *Fe*-P-C and *Pd*-Si made by splat cooling, in terms of a microcrystallite model, consistent with crystal diameters between 11 and 16 Å.

3.6. Annealing behaviour

[See also refs. 60, 67, 100, 108, 119, 139, 141-2, 145, 149, 157-8, 163-4, 191, 193, 197, 202, 204, 206, 231-3, 235, 239-41, 248, 306-7, 323, 332, 350, 352-3, 355-9, 362, 364-7, 369-71, 375, 385a, 386, 392, 401a, A10, A23, A25, A26, A29, A31, A34-6, A38, A40, A44, A50, A53, A55-6, A59, A65]

259. E. BABIĆ, R. KRSNIK, B. LEONTIĆ, and A. TONEJC, "Resistometric Analysis of Formation of a New Phase in a Supersaturated Solution of Fe in Al", *Phys. Stat. Sol.* a3 (1970) 71-4.

Reported resistivity changes during isochronal annealing of extended solid solutions containing 0.4 to 4.2 at.% Fe in Al. A phase transition at ~300°C attributed to precipitation of metastable $FeAl_6$ had an activation energy of 1.2 to 0.4 eV independent of concentration between 0.67 and 1.32 at.% Fe.

260. E. BABIĆ, R. KRSNIK, B. LEONTIĆ, and I. ZORIĆ, "A Study of Phase Transformations in Ultra-rapidly Quenched Al-Fe Alloys", *Fizika* **2** Suppl. 2 (1970) 22.1-22.4. Discussion 22.5-22.6.

See [259], (QT: 9b.)

261. E. BLANK, "Precipitation and Annealing-out of Lattice Defects in Splat-Cooled Al-Fe Alloy", *Fizika* **2** Suppl. 2 (1970) 24.1-24.7. Discussion 24.8-24.9.

Reported resistivity changes and TEM for isochronal annealing of Al-0.05 to 2 at.% Fe extended solid solutions made by a piston-and-anvil technique. Four stages of precipitation with increasing temperature were distinguished involving coherent GP zones, a distorted probably bcc transitional phase, semi-coherent rod-shaped precipitates and finally incoherent particles. See also [A3-A5].

262. S. K. BOSE and R. KUMAR, "Recrystallization of Rapidly Solidified Al-Cu Alloys—A Metallographic Study", *Trans. Indian. Inst. Metals* **23** No. 4 (1970) 53-8.

Reported annealing behaviour in the range 110 to 450°C for Al-4, 7.5 and 12 wt% Cu quenched from the melt. (QT: 4b, $z = 150$ μm.)

263. L. M. BUROV, "Breakdown of Supersaturated Solid Solutions of Alloys of Al", *Izv. Vuzov. Fizika* **1964** (3) 35-40 (in Russian). See *Chem. Abs.* **61** (1964) 13015g.

Reported annealing behaviour at 450 to 500°C of Al-1.1 to 4.3 wt% Mn, Al-0.7 to 2.9 wt% Cr and Al-0.37 to 5.80 wt% Mn-1.70 to 3.75 wt% Cr extended solid solutions quenched from the melt at $dT/dt \sim 5 \times 10^4$ K sec^{-1}. It was found in the ternary alloys that Mn governed the first stage of precipitation and Cr the last.

264. L. M. BUROV, "Determining the Activation Energy of Solid Solution Disintegration in the Alloys of Al-Mn and Al-Cr," *Phys. Metals Metallog.* **22** No. 1 (1966) 128-30. (From *Fiz. Metal. Metalloved.* **22** (1966) 124-5.)

Determined by XRD activation energies of 42.6, 38.0 and ~55 kcal mol^{-1} for decomposition of extended solid solutions in Al of 2.3 wt% Mn, 3.77 wt% Mn and 1.85 or 2.9 wt.% Cr respectively. These activation energies, up to twice those for solid state quenched *Al*-Mg and *Al*-Cu solid solutions decomposing at 150 to 200°C, reflected increased stability of these *Al*-Mn and *Al*-Cr solid solutions, decomposing at 400 to 500°C when made by quenching the melt. ($dT/dt \sim 4$ to 5×10^4 K sec^{-1}.)

265. J. J. BURTON and R. P. RAY, "Crystallization of an Amorphous Pd-Si Alloy", *J. Non-Crystalline Solids* **6** (1971) 393-6.

Reported resistivity indications of an interface-controlled first stage of crystallization on annealing of AS Pd-18.2 at.% Si alloy quenched from the melt by a piston-and-anvil technique. ($z = 20$ to 50 μm.)

266. H. C. DONKERSLOOT and J. H. N. VAN VUCHT, "Martensitic Transformation in Au-Ti, Pd-Ti and Pt-Ti Alloys near the Equiatomic Composition", *J. Less-Common Metals* **20** (1970) 83-91.

Reported determination by XRD of the composition dependence of martensitic-transformation characteristics in AuTi, PdTi and PtTi quenched from the melt. (QT: 1c, $z = 10$ to 20 μm.)

267. P. FERRAGLIO, K. MUKHERJEE, and L. S. CASTLEMAN, "Martensitic Transformation in a Splat-Cooled Au-50 at.% Cd alloy", *Acta Metallurgica* **18** (1970) 1067-70.

Reported XRD and TEM studies of the isothermal transformation to martensite of the high-temperature CsCl-type β-phase of Au-50 at.% Cd retained on quenching the melt. (QT: 1e.) See also [58, 286].

268. A. FONTAINE, J. DIXMIER, and A. GUINIER, "Mechanical Properties and Precipitation in Supersaturated Al-Mn and Al-Fe Alloys Obtained by Ultrarapid Quenching", *Compt. Rendus Acad. Sci. Paris* **B271** (1970) 231-4 (in French). See *Metals Abs.* **4** No. 3 (1971) 14-0074.

Reported microhardness and TEM studies of annealing of Al-3 at.% Mn and Al-3 at.% Fe extended solid solutions. (QT: 7b.) The larger hardness of the Al-Fe c.f. the Al-Mn alloy as-quenched (300 c.f. 100 kg mm^{-2}) and its continuous decline in 10 min to 10 days at 300°C, were attributed to higher lattice distortion in the as-quenched Al-Fe solid solution.

269. A. FONTAINE, J. DIXMIER, and A. GUINIER, "Mechanical Properties and Structural Transitions in Splat-Cooled Al-Mn and Al-Fe Alloys", *Fizika* **2** Suppl. 2 (1970) 23.1-23.6. Discussion 23.7.

Extension of [268].

270. Y. FUJINAGA, S. NAGAKURA, and S. OKETANI, "Structure of Al-Cu Alloy Rapidly Quenched from the Liquid State and Precipitation from Enforced Solid Solution", *Nippon Kinzoku Gakkai-Si* (*J. Japan Inst. Metals*) **32** (1968) 1210-6 (in Japanese). See *Metals Abs.* **2** No. 8 (1969) 12-0912.

Reported XRD and TEM studies indicating TSSE up to 5 at. % Cu in Al in thick and thinner parts of specimens quenched from the melt on to a rotating cylinder. Precipitation on annealing had the same sequence GP $\rightarrow \theta'' \rightarrow \theta' \rightarrow \theta$ as for purely solid-state quenched alloys and precipitation temperature increased with Cu-content. See also [139].

271. P. FURRER, "Examination of Precipitation Processes in Thin Foils by combined Scanning and Transmission Electron Microscopy", *Beitr. elektronenmikroskop. Direktabb. Oberfl.* **4/2** (1971) 463-75 (in German).

Reported application of scanning electron microscopy and TEM to the study of precipitation on annealing, including extended *Al*-Fe solid solutions made by quenching the melt.

272. M.H.JACOBS, A.G.DOGGETT, and M.J.STOWELL, "A Study of Microstructure and Phase Transformations in an Annealed Rapidly Quenched Al-8 wt% Fe Alloy", *Fizika* **2** Suppl. 2 (1970) 18.1-18.6. Discussion 18.7-18.8.

Reported TEM observations of decomposition on annealing > 300°C of Al-8 wt% Fe extended solid solution. (QT: 1a.) A fine-scale network of metastable bcc FeAl crystallites within the grains of as-quenched, extended *Al*-Fe solid solution, formed needles of equilibrium $FeAl_3$ which subsequently spherodized, while metastable $FeAl_6$ grew initially at grain boundaries.

273. M. H. JACOBS, A. G. DOGGETT, and M. J. STOWELL, "A Study of Three Decompositions Mechanisms in a Splat Quenched Al-8 wt % Fe-3 wt % Mn Alloy", in "*Proc. 25th Anniv. Meeting of Electron Microscopy and Microanalysis Group*" (Institute of Physics, London, 1971) pp. 284-7.

Reported TEM study of the decomposition on annealing >300°C of single phase extended solid solution, extended solid solution with a fine scale network of second phase and two-phase eutectic like microstructure observed in Al-8 wt % Fe-3 wt % Mn alloy (QT: 1a), each forming particles of (Fe, Mn)Al_6 in an Al matrix by distinct annealing mechanisms.

274. A. KIRIN and A. BONEFAČIĆ, "Decomposition Study of Al-Sn Solid Solutions obtained by Rapid Quenching from the Melt", *Fizika* **2** Suppl. 2 (1970) 14.1-14.4. Discussion 14.5.

Reported effect of isochronal annealing up to 350°C on lattice parameter of extended solid solutions of up to 0.026 at. % Sn in Al. (QT: (26), *z* up to 20 μm.)

275. L. F. KOLOMOYTSEVA, N. I. VARICH, and L. M. BUROV, "Decomposition of Highly Supersaturated Solid Solutions in Al-W Alloys", *Phys. Metals Metallog.* **28** No. 5 (1969) 16-20. (From *Fiz. Metal. Metalloved.* **28** (1969) 782-6.)

Reported effect of annealing at 600 to 650°C on lattice parameter, resistivity and microstructure of extended solid solutions of 2.8, 4.95 and 6.4 wt % W in Al. (QT: 3a, $dT/dt \sim 10^6$ K sec^{-1}.) Decomposition at 600°C in 11 to 40 h increasing with increasing melt superheat prior to quenching.

276. U. KÖSTER, "Microscopic Investigations on the Transformation of Metastable Phases into Stable Phases in Al-Ge Alloys", *Fizika* **2** Suppl. 2 (1970) 12.1-12.6. Discussion 12.7-12.8.

Reported TEM and XRD of decomposition of rhombohedral γ_1 and hexagonal γ_2 metastable phases formed in Al-20 and 50 wt % Ge alloys made by water-quenching and splat cooling. Decomposition was complete in 1 h at 200°C.

277. V. V. KOVALENKO and A. F. POLESYA, "Decomposition Kinetics of Supersaturated Solid Solutions of Al-Cu-Cr", *Phys. Metals Metallog.* **27** No. 4 (1969) 192-3. (From *Fiz. Metal. Metalloved.* **27** (1969) 758-60.)

Reported effect of annealing at 150 to 350°C on the lattice parameter of extended solutions of 5 wt % Cu in Al containing additions of 0.4, 0.8 and 1.2 wt % Cr. (QT: 3a, $dT/dt \sim 10^5$ to 10^6 K sec^{-1} and chill casting, $dT/dt \sim 10^3$ K sec^{-1}.)

278. K. KRANJC and M. STUBIČAR, "Microhardness and Small-Angle X-ray Scattering Study of an Al-16 wt % Ag Alloy Quenched From the Melt", *Fizika* **2** Suppl. 2 (1970) 31.1-31.6. Discussion 31.6.

Compared by microhardness and XRD the effect of quenching from liquid (two-piston method) and from solid on isochronal annealing of supersaturated Al-16 wt % Ag solid solution. No GP zones were detected up to 3 months at room temperature for splat-cooled specimens and they reached maximum hardness on ageing at a lower temperature than for solid-quenched specimens.

279. K. KUMADA, Y. SUMITOMO, S. NENNO, and M. YAMAMOTO, "Formation of the Ll_2 Type Superlattice Al_3Mg in Liquid-Quenched Al-Mg Alloys", *J. Japan Inst. Metals* **34** (1970) 1062-6 (in Japanese). See *Metals Abs.* **4** No. 5 (1971) 12-0644.

Reported formation, on annealing for $\frac{1}{2}$ h at 100°C, of Ll_2-ordered Al_3Mg in Al-21.2 and 26.2 at % Mg extended solid solutions made by quenching the melt. Alloys containing up to 36.8 at. % Mg were studied by XRD and TEM.

280. R. KUMAR and S. K. BOSE, "Metallographic Studies of Rapidly Solidified Al-Cu Alloys", Proc. 3rd Annual Meeting of Internat. Metallog. Soc. 1970

(Los Alamos, 1971) pp. 95-8. See *Metals. Abs.* **5** No. 2 (1972) 12-0231.

See [262].

281. R. KUMAR and S. K. BOSE, "Structural Stability of Rapidly Solidified Al-Cu Supersaturated Solid Solutions", *Scripta Metall.* **5** (1971) 515-8.

Reported effect of Cu content between 4 and 20 wt % in Al on microhardness and lattice parameter as-quenched and annealed for $\frac{1}{2}$ h at 250, 350 and 450° C. (QT: 4b, $z = 100$ to 150 μm.)

282. D. KUNSTELJ and A. BONEFAČIĆ, "A Metallographic Study of Decomposition of a Supersaturated Al-Rich Al-Fe Solid Solution", *Metallography* **2** (1969) 329-36.

Detected by replica TEM and microprobe analysis cellular decomposition in ~1 month of an extended Al-0.68 at.% Fe solid solution made by splat cooling. ($z = 10$ to 100 μm.)

283. D. KUNSTELJ and A. BONEFAČIĆ, "Decomposition of a Supersaturated Al-Rich Al-Fe Solid Solution during Annealing", *Metallography* **3** (1970) 79-87.

Reported study by replica TEM of decomposition by isochronal annealing at 150 to 500° C of Al-0.68 at.% Fe extended solid solution made by splat cooling. Cellular decomposition up to 300° C was superseded by precipitate coagulation at higher *T*.

284. R. K. LINDE, "Kinetics of Transformation of Metastable Ag-Cu Solid Solutions Quenched from the Liquid State", *Trans. Met. Soc. AIME* **236** (1966) 58-64.

Reported study by XRD, resistivity measurements and metallography of decomposition of Ag-11.2, 25 and 39.9 at.% Cu extended solid solutions, (QT: 6b, $z = 50$ to 150 μm) at *T* up to 350° C. Decomposition occurred discontinuously with activation energies of 33.1 ± 2.0 and 33.6 ± 2.5 kcal mol^{-1} for Ag-25 and 39.9 at. % Cu respectively.

285. M. MOSS and M. M. KARNOWSKY, "Annealing Kinetics of Metastable Al-Mn Alloy", *Bull. Amer. Phys. Soc.* **14** (1969) 834 only. Abstract only.

Reported study by XRD, metallography, microhardness and resistivity measurements of decomposition at 300 to 350° C of extended Al-1.7 at. % Mn solid solution made by plasma spraying (QT: 1b), obtaining activation energy for decomposition of 1.73 ± 0.3 eV. See also M. M. KARNOWSKY, *World Aluminium Abstracts* **5** (1972) 54-0002.

286. K. MUKHERJEE and P. FERRAGLIO, "Martensitic Transformation in a Splat Cooled Metastable Au-47.5 at.% Cd Alloy", *Fizika* **2** Suppl. 2 (1970) 27.1-27.6. Discussion 27.7.

Reported martensitic transformation under electron microscope beam heating of high temperature β Au-47.5 at. % Cd retained by splat cooling. (QT: 1e.) See also [58, 267].

287. A. F. POLESYA and A. L. STEPINA, "Disintegration Kinetics of Supersaturated Binary and Ternary Solid Solutions of Al with Cr and Mo Prepared by Quenching from the Molten State", *Phys. Metals Metallog.* **30** No. 5 (1970) 35-41. (From *Fiz. Metal. Metalloved.* **30** (1970) 929-35.)

Reported study of decomposition on annealing of extended solid solutions of *Al*-Mo, *Al*-Cr and *Al*-Cr-Mo quenched from the melt at $dT/dt \sim 10^6$ to 10^7 K sec^{-1}. While Al-0.4 wt % Mo was fairly stable up to 600° C, Al-Cr with or without Mo decomposed at 475° C with precipitation involving Cr.

288. P. K. RASTOGI, "Determination of the Activation Energy for the Growth of Clusters in an Amorphous Fe-P-C Alloy", *Scripta Metall.* **4** (1970) 939-40.

Calculated from the resistivity behaviour just below the crystallization *T*, an activation energy of 25.7 kcal mol^{-1} for the growth of Fe_2P clusters in AS Fe-15 at. % P-10 at. % C made by quenching the melt. See also [289] and *J. Mater. Sci.* **8** (1973) 140-3.

289. P. K. RASTOGI and P. DUWEZ, "Rate of Crystallization of an Amorphous Fe-P-C Alloy", *J. Non-Crystalline Solids* **5** (1970) 1-16.

Reported study by thermal analysis, XRD, TEM and resistivity of decomposition of AS Fe-15 at. % P-10 at. % C (QT: 6b, $z \sim 40$ to 50 μm) by continuous heating at rates between 1 and ~320 K min^{-1}. See also [289].

290. R. ROBERGE and H. HERMAN, "A Study of Phase Decomposition in Liquid-Quenched Al-Ag Alloys", *Fizika* **2** Suppl. 2 (1970) 6.1-6.5. Discussion 6.6.

Reported TSSE of Ag in Al (QT: 2b and gun [26]) and XRD (high angle and low angle), TEM and resistivity studies indicating that more homogeneous solid solutions were produced by quenching liquid than by quenching solid alloys.

291. T. I. SHEYKO and L. M. BUROV, "Behaviour of the Width of X-ray Interference Lines of the Rapidly Cooled Alloy Al-Mo in the Range 150 to 615° C", *Phys. Metals Metallog.* **31** No. 4 (1971) 207-8. (From *Fiz. Metal. Metalloved.* **31** (1971) 880-2.)

Reported maximum in (200) and (422) X-ray line broadening at ~200° C, attributed to relief of quenching stresses, on annealing Al-1.5 wt % Mo extended solid solution made by a gun technique. ($z = 90$ μm.) cf. [292].

292. T. I. SHEYKO and L. M. BUROV, "Dependence of the Width of X-ray Diffraction lines of an Al-V Alloy Cooled at Very Fast Rates on Ageing Temperature", *Phys. Metals Metallog.* **32** No. 2 (1971) 219-21. (From *Fiz. Metal. Metalloved.* **32** (1971) 441-2.)

Reported decreased X-ray line broadening above ~ 175° C, attributed to a decrease in dislocation density on annealing Al-1.1 wt % V extended solid solution made by quenching the melt ($dT/dt \sim 10^6$ K sec^{-1}). cf. [291].

293. P. H. SHINGU, J. TAKAMURA, and M. KAWASHIMA, "Quenching from Liquid of Metals and Alloys", *Suiyokwai-Shi* **16** (1968) 472-5 (in Japanese). See *Metals Abs.* **2** No. 3 (1969) 13-0240.

Reported TEM observations of rows of fine precipitates or strain contrast features, attributed possibly to nucleation on dislocations, on room temperature ageing of dilute *Al*-Au and *Al*-Cu alloys quenched from the melt. (QT: 1g.)

294. A. TONEJC, "X-ray Study of the Decomposition of Metastable Al-Rich Al-Fe Solid Solutions", *Metall. Trans.* **2** (1971) 437-40.

Reported XRD study of isochronal and isothermal annealing of Al-3.6 at. % Fe extended solid solution. (QT: 7b.) Decomposition to produce equilibrium $FeAl_3$ second phase took place via formation of metastable $FeAl_6$ which persisted for as long as 670 h at 300°C.

295. A. TONEJC and A. BONEFAČIĆ, "X-ray Study of Al-Rich Al-Fe Alloys Quenched from the Melt", *Fizika* **2** Suppl. 2 (1970) 20.1-20.4. Discussion 20.5-20.6.

See [294].

296. W. VANDERMEULEN and A. DERUYTTERE, "The Decomposition of the γ-Phase of a Cu-27 wt % Sn Alloy", in *The Mechanism of Phase Transformations in Crystalline Solids*, Institute of Metals (London) Monograph No. 33 (1969) pp. 294-6.

Included some TEM information on decomposition on annealing of δ and γ phases retained in Cu-27 wt % Sn splat cooling. (QT: 1d and 6b.)

297. N. I. VARICH, L. M. BUROV, and K. YE. KOLESNICHENKO, "Influence of a Third Component on the Physical Properties of the Alloy Al-Mn", *Phys. Metals Metallog.* **18** No. 3 (1964) 78-83. (From *Fiz. Metal. Metalloved.* **18** (1964) 396-400.)

Reported study, by XRD, microhardness, paramagnetic susceptibility, thermoelectric power and resistivity, of decomposition on annealing of Al-3.45 to 3.98 wt % Mn extended solid solutions (QT: 2a) with additions (0.22 to 100 wt %) of W, V, Zr, Ti, Be, Ni, Re, Cu, Fe, Co, Mo or Ta, which delayed decomposition considerably in most cases. cf. [298] for *Al*-Cr.

298. N. I. VARICH, L. M. BUROV, and K. YE. KOLESNICHENKO, "Effect of a Third Component on the State of Solid Solutions of the Al-Cr obtained at High Cooling Rates", *Izv. VUZ Tsvet. Met* **10** No. 3 (1967) 111-4 (in Russian). See *Metall. Abs.* **2** (1967) 1513.

Reported study effect of same ternary additions as in [297] on the decomposition of Al-1.44 to 1.95 wt % Cr extended solid solutions, the additions of W, Ta, Mo and Re greatly delaying decomposition.

299. R. H. WILLENS, "Dendritic Crystallization of an Amorphous Alloy", *J. Appl. Phys.* **33** (1962) 3269-70.

Reported dendritic crystal growth produced by electron microscope beam heating in AS Te-15 at. % Ge quenched from the melt by a gun technique. (z up to 10 μm.)

3.7.A. Electrical and magnetic properties

[See also refs. 18, 39, 95, 96, 163-5, 181, 205, 230-1, 235, 241, 259-61, 275, 287-90, 297-8, 384-5, 388, 389a, 400, A3, A6, A7, A9, A17-19, A24, A38, A41, A51-2, A57, A60, A65a]

300. E. BABIĆ, R. KRSNIK, and B. LEONTIĆ, "A Method of Electrical Measurements on Very Small Samples of Ultra-Rapidly Quenched Alloys for Temperature Intervals from 1.5 to 700 K", *J. Phys. E: Sci. Instrum.* **3** (1970) 664-6.

Described method for preparation of contacts for electrical measurements on small samples of extended solid solutions of Fe in Al made by quenching the melt.

301. E. BABIĆ, R. KRSNIK, B. LEONTIĆ, Z. VUČIĆ, I. ZORIĆ, and C. RIZZUTO, "High-Temperature Spin-Fluctuation Resistivity in AlMn", *Phys. Rev. Letters* **27** (1971) 805-8.

Reported linear decrease of resistivity with increasing T above 50 K for extended solid solutions of 2.66 to 5 wt % Mn in Al (QT: 9b), while following at lower T the T^2 behaviour of more dilute alloys. Possible explanations in terms of localized spin fluctuations were discussed.

302. E. BABIĆ, R. KRSNIK, B. LEONTIĆ, and I. ZORIĆ, "Enhanced Superconductivity in Ultrarapidly Quenched Bulk Al-Cu Alloy", *Phys. Rev.* **B2** (1970) 3580-2.

Reported a linear increase in superconducting transition T up to 2.95 K with increasing residual resistance (related to dT/dt) for Al-0.85 at. % Cu alloy solid solution made by quenching the melt. (QT: 9b, $dT/dt \sim 10^6$ K sec^{-1}.)

303. E. BABIĆ, R. KRSNIK, B. LEONTIĆ, and I. ZORIĆ, "Enhancement of Superconductivity in Rapidly Quenched Samples of Al Alloys", *Fizika.* **2** Suppl. 2 (1970) 3.1-3.5. Discussion 3.5.

See [302].

304. E. BABIĆ, B. LEONTIĆ, and M. VUKELIĆ, "A Thyristor Device for Pulse Spot-Welding of Thin Wires and Foils", *J. Phys. E: Sci. Instrum.* **4** (1971) 382-3.

Described spot-welding device for obtaining reproducible contact welds on small samples, such as Al alloys rapidly quenched from the melt, allowing low resistances to be measured without interference from parasitic emfs.

305. E. BABIĆ, C. RIZZUTO, and F. SALAMDNI, "Superconducting Transition Temperature Measure-

ments on Supersaturated Alloys of Fe in Al", *J. Phys. F: Metal Physics* **1** (1971) L18-L20.

Reported and discussed dependence of superconducting transition T on residual resistivity ratio for extended solid solutions of Fe in Al. (QT: 9b, $z \sim 15$ μm.) cf. [302, 303].

306. P. DUWEZ and S. C. H. LIN, "Amorphous Ferromagnetic Phase in Fe-C-P Alloys", *J. Appl. Phys.* **38** (1967) 4096.7.

Reported magnetic behaviour typical of a soft ferromagnetic alloy (saturation magnetization $\sim$ 6.8 kG, coercive force $\sim$ 3 Oe, Curie $T \sim 320°$C) for AS Fe-6 wt % P-1.7 wt % C quenched from the melt by a piston-and-anvil method. ($z \sim 50$ μm.) The AS phase crystallized at 420°C with an energy release $\sim$900 cal mol^{-1} when heated at $\sim$100 K min^{-1}.

307. P. DUWEZ and C. C. TSUEI, "Semiconducting Amorphous Phase in Te-Cu-Au Alloys", *J. Non-Crystalline Solids* **4** (1970) 345-6. An extended abstract.

Reported and discussed resistivity, thermoelectric power, Mössbauer and annealing studies of semiconducting AS Te-25 at. % Cu-5 at. % Au made by quenching the melt.

308. R. HASEGAWA, "Magnetic Properties of Amorphous Pd-Si Alloys Containing Fe", *J. Appl. Phys.* **41** (1970) 4096-100.

Reported and discussed dependence on T up to 300 K of magnetic properties of AS (Fe_xPd_{80-x})-20 at.% Si where $x = 0.57$ to 7 (QT: 6b), including ferromagnetism with a Curie T of 28 K in AS Pd-7 at.% Fe-20 at.% Si.

309. R. HASEGAWA, "Magnetic Properties of an Amorphous Mn-P-C Alloy", *Phys. Rev.* **B3** (1971) 1631-4.

Reported and discussed, in relation to results for the same alloy in crystalline form, the dependence on T up to 300 K of magnetic properties of AS Mn-15 at.% P-10 at.% C quenched from the melt by a piston-and-anvil method.

310. R. HASEGAWA, "A Simple Model for Amorphous Antiferromagnets", *Phys. Stat. Sol.* **B4** (1971) 613-7. (From CALT-822-16, December 1970.)

Considered a molecular field model for amorphous antiferromagnets, in relation to the magnetic properties of AS Mn-P-C made by quenching the melt.

311. R. HASEGAWA, "Resistivity of Nearly Ferromagnetic Amorphous Alloys", *Phys. Letters* **36A** (1971) 207-8.

Accounted for Kondo resistivity minimum found in AS Pd-Si, Pd-Co-Si, Fe-Pd-P and Fe-P-C made by quenching the melt by means of an approximate calculation of the resistivity due to electron-magnon interactions, combined with unanomalous T^2 behaviour, cf. [312].

312. R. HASEGAWA, "Electrical Resistivity of Amorphous Metallic Alloys", *Phys. Letters* **36A** (1971) 425-6.

Discussed in relation to the quasi-gas of amorphous solids the unanomalous (cf. [311]) linear T-dependence of resistivity for $T \gg 100$ K for AS Mn_xPd_{80-x}-20 at.% Si made by quenching the melt.

313. R. HASEGAWA, "Magnetic States in Amorphous Fe-Pd-Si Alloys", *J. Phys. Chem. Solids* **32** (1971) 2487-92.

Reported and discussed low T measurements of electrical resistivity, magnetic susceptibility and magnetoresistivity for AS (Pd-18 at. % $Si)_{100-x}Fe_x$, where $0.1 < x < 0.9$, made by quenching the melt.

314. R. HASEGAWA, "Ferromagnetic Resonance in an Amorphous Co-Pd-Si Alloy", *Phys. Letters* **37A** (1971) 233-4. From CALT-822-38, October 1971.

Reported results of ferromagnetic resonance studies on AS Pd-10 at. % Co-20 at.% Si made by quenching the melt, interpreted as the result of an s-d exchange interaction.

315. R. HASEGAWA and C. C. TSUEI, "s-d Exchange Interaction in Amorphous Cr-Pd-Si and Mn-Pd-Si Alloys", *Phys. Rev.* **B2** (1970) 1631-43.

Reported dependence on T of electrical and magnetic properties of AS (Mn or Cr) $_xPd_{80-x}$-20 at.% Si where $0 < x < 7$. (QT: 6b.) Results were discussed in terms of the s-d exchange model.

316. R. HASEGAWA and C. C. TSUEI, "Kondo Effect in Amorphous Fe-Pd-Si and Co-Pd-Si Alloys", *Phys. Rev.* **B3** (1971) 214-9.

Reported and discussed concurrence of a Kondo resistivity minimum and ferromagnetism at low T in AS (Fe or Co)$_x$ Pd_{80-x}-20 at. % Si where $x = 0$ to 7 for Fe and 0 to 11 for Co. (QT: 6b.)

317. V. K. C. LIANG and C. C. TSUEI, "Concentration Dependence of Kondo Temperature and Unitarity Limit in Non-Dilute Magnetic Amorphous Alloys", *Solid State Commun.* **9** (1971) 579-82.

Reported and discussed dependence on T of resistivity for AS (NiPd)-18 at. % B containing 4 at.% Cr made by quenching the melt ($dT/dt \sim 10^5$ K sec^{-1}).

318. S. C. H. LIN, "Resistivity Minimum in an Amorphous Ferromagnetic Alloy", *J. Appl. Phys.* **40** (1969) 2173-5.

Reported dependence on ratio of resistances at liquid He and room temperature of resistivity minimum occurring in the range 10 to 50 K for AS Fe-13 at.% P-7 at. % C quenched from the melt.

319. S. C. H. LIN, "Hall Effect in an Amorphous Ferromagnetic Alloy", *J. Appl. Phys.* **40** (1969) 2175-7.

Reported a small dependence on T of the spontaneous Hall coefficient of AS Fe-13 at. % P-7 at. % C quenched from the melt, consistent with a free electron assumption of its origin.

320. H-L. LUO, "Superconductivity and Lattice Parameters in fcc Pt-W and Pd-W Solid Solutions", *J. Less Common Metals* **15** (1968) 299-302.

Reported superconductivity at high concentrations, and minima in the lattice parameter-composition curves at low concentrations, for extended solid solutions of W in Pd and Pt. (QT: 1c.)

321. H-L. LUO, M. F. MERRIAM, and D. C. HAMILTON, "Superconducting Metastable Compounds", *Science* **145** (1964) 581-3.

Reported superconductivity in several MCS phases in alloys of Ge or Te with Au or Ag made by quenching the melt. (QT: [26].)

322. H-L. LUO and R. H. WILLENS, "Superconducting Transitions in bcc Tl-In Alloys", *Phys. Rev.* **154** (1967) 436-8.

Reported dependence on composition of superconducting transition T and lattice parameter of extended solid solutions of In in Tl. (QT: [26].)

323. P. MAITREPIERRE, "Electrical Resistivity of Amorphous Ni-Pd-P Alloys", *J. Appl. Phys.* **41** (1970) 498-503.

Reported dependence on T of resistivity of AS Pd-13 to 73 at. % Ni-15 to 20 at. % P. (QT: 6b.) A Kondo effect below 15 K was attributed to Fe impurities, while progressive crystallization occurred above 570 K.

324. B. T. MATTHIAS, T. H. GEBALLE, R. H. WILLENS, E. CORENZWIT, and G. W. HULL, "Superconductivity of Nb_3Ge", *Phys. Rev.* **139** (1965) A1501-3.

Reported increase of superconducting transition T from 6.9 K for nonstoichiometric equilibrium Nb_3Ge to as high as 17 K for metastable stoichiometric Nb_3Ge made by quenching the melt. (QT: 1c.)

325. E. A. NESBITT, R. H. WILLENS, H. J. WILLIAMS, and R. C. SHERWOOD, "Magnetic Properties of Splat-Cooled Fe-Co-V Alloys", *J. Appl. Phys.* **38** (1967) 1003-4.

Reported magnetic properties of splat-cooled Fe-O to 20 wt% V-52 wt% Co. Coercive forces were high (850 Oe) for 20 wt% V after ageing. Alloys with ~ 14 wt% V were paramagnetic at 300 K but ferromagnetic at 1.4 K, behaviour accounted for by superparamagnetic particles ~50 Å diameter identified by TEM.

326. L. R. NEWKIRK and C. C. TSUEI, "Superconducting Transition Temperatures and Lattice Parameters of Simple Cubic Metastable Te-Au Solutions Containing Fe and Mn", *Phys. Rev.* **B3** (1971) 755-61.

Reported superconducting transition T and lattice parameters of metastable simple cubic solid solutions (QT: [26]) of Au in Te as a function of concentration of added Fe or Mn. Behaviour was interpreted in terms of the Fermi surface/Brillouin zone interaction invoked previously [340] in the absence of Fe and Mn additions.

327. L. R. NEWKIRK and C. C. TSUEI, "Augmented-Plane-Wave Calculation of Energy Bands in Simple Cubic Te", *Phys. Rev.* **B4** (1971) 2321-4.

Extrapolated lattice parameter results for metastable *Te*-Ag to yield value for hypothetical simple cubic Te. Electronic properties deduced from the calculated band structure were reported to be similar to those of a high pressure Te phase existing between 40 and 70 kbar at room temperature.

328. L. R. NEWKIRK and C. C. TSUEI, "Mössbauer Study of Hyperfine Magnetic Interactions in Fe-Ga Solid Solutions", *Phys. Rev.* **B4** (1971) 4046-53.

Reported and analysed as a function of composition and configuration Mössbauer spectra for extended bcc solid solutions of up to 25 at. % Ga in Fe. (QT: 6b.)

329. Ö. RAPP, "Superconductivity and Lattice Parameters in the Zr-Mo, Zr-W, Hf-Mo and Hf-W Alloy Systems", *J. Less Common Metals* **21** (1970) 27-44.

Reported and discussed measurements of superconducting transition T and lattice parameters as a function of composition in extended bcc solid solutions of 3 to 41 at. % Mo in Zr and 9 to 67 at. % Mo in Hf and in corresponding Zr-W and Hf-W alloys. (QT: 1c.)

330. J. F. SADOC, "Experimental Study of the Magnetic Susceptibility of Solid Solutions of First Series Transition Elements in Al", *J. Phys. Chem. Solids*, **32** (1971) 2765-71 (in French). See *Phys. Abs.* **72** (1972) 13373.

Reported dependence on T and concentration of susceptibility for extended solid solutions of 0.5 to 4.8 at. % Ti, V, Cr, Fe, Mn, Co or Ni in Al made by splat cooling. The strong paramagnetic contribution of transition metals in the centre of the transition series was in accord with theory but a diamagnetic contribution was not understood.

331. T. E. SHARON and C. C. TSUEI, "Mössbauer Effect Study of Amorphous Fe-Pd-Si Alloys", *Solid State Commun.* **9** /1971) 1923-7.

Reported that Mössbauer spectra of AS Fe_xPd_{80-x} -20 at. % Si where $0 < x < 7$ (QT: 6b) were not consistent with the superparamagnetic interpretation advanced previously [308] on the basis of magnetic properties alone. Proposed a new model based on local ferromagnetic order of randomly changing direction throughout the material.

331a. T. E. SHARON, "Magnetism in an Amorphous Fe-Pd-P Alloy System", Calif. Inst. Tech. Thesis (1971) 157 pp. From *Phys. Abs.* **75** (1972) 65114.

Reported preparation and examination of amorphous $Fe_xPd_{80-x}P_{20}(13 \leqslant x \leqslant 44)$. The Mössbauer effect was used to study the hyperfine field, and a variation of T_c with composition was reported. It was concluded that weakly-coupled Fe resides in a low effective field. These Fe atoms participate in a spin-flip scattering process resulting in a Kondo effect (resistivity minimum).

332. A. K. SINHA, "Electrical Resistivity, Thermoelectric Power and X-Ray Interference Function of Amorphous Ni-Pt-P Alloys", *Phys. Rev.* **B1** (1970) 4541-6.

Reported and discussed dependence on T and composition of resistivity, thermo-electric power and XRD spectrum of AS (Ni_xPt_{1-x})-25 at.% P, where $0.20 < x < 0.60$, quenched from the melt by a piston-and-anvil method. ($z \sim 35$ μm.)

333. A. K. SINHA, "Electrical Resistivity and Magnetic Susceptibility of Amorphous Cr-Ni-Pt-P Alloys", *J. Appl. Phys.* **42** (1971) 5184-6.

Reported and discussed dependence on T and composition of resistivity and susceptibility of AS $(Cr_xNi_{0.30-x}Pt_{0.70})$-25 at.% P, where $0.0 \leqslant x \leqslant 0.06$, quenched from the melt by a piston-and-anvil method.

334. J. D. SPEIGHT, "Structure and Magnetic Properties of Rapidly Quenched Sm-Type Alloys", *J. Less Common Metals* **20** (1970) 251-62.

Reported and discussed dependence of T of susceptibility measurements of metastable cph Gd-30% (La or Ce), Gd-35% Pr and Gd-50% Nd phases. (QT: 1e.)

335. C. C. TSUEI, "Electrical Resistance and Thermoelectric Power of an Amorphous $Te_{70}Cu_{25}Au_5$ Alloy", *Phys. Rev.* **170** (1968) 775-9.

Reported and discussed dependence on T over the range 80 to 300 K of resistivity and thermoelectric power of AS Te-25 at.% Cu-5 at.% Au. (QT: 1a, $z \gtrsim 10$ μm.)

336. C. C. TSUEI and P. DUWEZ, "Metastable Amorphous Ferromagnetic Phases in Pd-Base Alloys", *J. Appl. Phys.* **37** (1966) 435 only.

Reported formation of AS phases in Pd-20 at.% Si containing additions of 5 at.% Fe, 12 at.% Co or 15 at.% Ni, ferromagnetic behaviour being induced by the Fe and Co additions.

337. C. C. TSUEI and R. HASEGAWA, "Kondo Effect in Amorphous Pd-Si Alloys containing Transition Metals", *Solid State Commun.* **7** (1969) 1581-5.

Reported concentration dependence, and in some cases co-existence with ferromagnetism of a Kondo resistivity minimum in AS $(Pd_{80-x}R_x)$-20 at.% Si where $0 < x < 7$ for R = Cr, Mn or Fe and $0 < x < 11$ for R = Co, not present for $0 < x < 15$ for R = Ni or $0 < x < 5$ for R = Cu. (QT: 6b.)

338. C. C. TSUEI and E. KANKELEIT, "Mössbauer Effect of Te^{125} in Simple-Cubic and Amorphous Te-Base Alloys", *Phys. Rev.* **162** (1967) 312-4.

Reported and discussed Mössbauer spectra of metastable simple cubic Te_2Au and AS Te-25 at.% Au (QT: [26]) in relation to results for equilibrium monoclinic Te_2Au and crystalline pure Te, respectively.

339. C. C. TSUEI, G. LONGWORTH, and S. C. H. LIN, "Temperature Dependence of the Magnetization of an Amorphous Ferromagnet", *Phys. Rev.* **170** (1968) 603-6.

Reported and discussed dependence on T of Mössbauer spectra and bulk magnetization of AS Fe-12.5 at.% P-7.5 at.% C quenched from the melt by a piston-and-anvil method.

340. C. C. TSUEI and L. R. NEWKIRK, "Fermi-Surface/Brillouin-Zone Interaction in Simple Cubic Te-Au Alloys", *Phys. Rev.* **183** (1969) 619-24.

Reported and interpreted in terms of Fermi surface/Brillouin zone interaction, composition dependence of lattice parameter, superconducting transition T and thermoelectric power for metastable simple cubic Te-15 to 40 at.% Au. (QT: [26], $z \gtrsim 10$ μm.)

341. C. C. TSUEI, H-C YEN, and P. DUWEZ, "Superconducting Metastable Simple Cubic Alloys", *Phys. Letters* **34A** (1971) 80-1.

Reported and discussed superconductivity and lattice parameter of metastable simple cubic Sb-25 at.% Au, Sb-16.5 at.% Pd, Sb-25 and 31.7 at.% In and Te-3.3 or 16.6 at.% Au. (QT: [26].)

342. M. E. WEINER, "Magnetic Moments in Amorphous Pd-Co-Si Alloys", *J. Metals* **20** No. 8 (1968) 99A. Abstract only.

Reported measurement, and discussion in terms of super-paramagnetic clustering, of magnetic moment as a function of Co content and T for AS $Pd_{80-x}Co_x$-20 at.% Si, where $3 < x < 11$, quenched from the melt.

343. R. H. WILLENS and E. BUEHLER, "The Superconductivity of the Monocarbides of W and Mo", *Appl. Phys. Letters* **7** (1965) 25-6.

Reported retention and superconductivity of high T cubic forms of WC, W_2C and MoC. (QT: 1e.)

344. R. H. WILLENS and E. BUEHLER, "Effect of Paramagnetic Impurities on the Superconducting Behaviour of Cubic MoC", *J. Appl. Phys.* **38** (1967) 405-6.

Reported and discussed dependence on concentration of added Cr, Fe or Mn of the superconducting transition T of cubic MoC. (QT: 1e.)

345. R. H. WILLENS, E. BUEHLER, and B. T. MATTHIAS, "Superconductivity of the Transition-Metal Carbides", *Phys. Rev.* **159** (1967) 327-30.

Reported and discussed formation, lattice parameters and superconducting transition T of continuous NaCl-structured solid solutions in binaries between NbC, TaC, WC and MoC. (QT: 1e.)

3.7.B. Mechanical properties

[See also refs. 29, 37, 61, 63, 116, 163-5, 172, 186, 201, 223, 230, 261, 268-9, 278, 281, 285, 373, 381, 385a, 389, 391, A3, A4, A8, A28-30, A33, A40, A50]

346. H. AHLBORN and D. MERZ, "Production, Structure and Properties of a Rapidly Solidified Al Alloy containing 8 wt% Fe. Pt. II Properties of Semi-Fabricates", *Aluminium* **47** (1971) 730-4 (in German). See *Metals Abs.* **5** No. 9 (1972) 52-0681. For Pt. I, see [51].

Reported microstructure and tensile properties of Al-8 wt% Fe rod compacted and extruded from splat-cooled flake. (QT: 4d.) Initial hardness of ~80 kg mm^{-2} decreased to ~ 50 kg mm^{-2} after 115h at 550°C while remaining unchanged after the same time at 300°C. Tensile strength exceeded that of SAP930 up to 400°C. Creep rupture data were also reported. See also [363].

347. G. BEGHI, R. MATERA, and G. PIATTI, "The Possibility of Fabrication of an Al-$NbAl_3$ Dispersed Phase Alloy by Rapid Cooling from the Liquid State", *J. Nucl. Mater.* **26** (1968) 219-22 (in French). See *Metals Abs.* **1** No. 9 (1968) 46-0076.

Reported tensile properties at 20, 400 and 450°C and microstructure for Al-10 wt% Nb quenched from the melt. (z ~0.1 to 1 mm, dT/dt ~10^4 K sec^{-}).

348. G. BEGHI, R. MATERA, and G. PIATTI, "Dispersed Phase Alloying of Al-$NbAl_3$ by Ultrarapid Quenching from the Molten State", *J. Nucl. Mater.* **31** (1969) 259-68 (in French). See *Metals Abs.* **3** No. 1 (1970) 31-0116.

Reported TEM studies and, at T up to 450°C, tensile property measurements on Al-10 wt% Nb rolled from cold and hot compacted sheets made by quenching the melt. (QT: 7c, z ~ 70 to 80 μm, dT/dt ~ 10^6 K sec^{-1}.)

349. G. BEGHI, R. MATERA, and G. PIATTI, "Superplastic Behaviour of a Splat-Cooled Al-17 wt% Cu Alloy", *J. Mater. Sci.* **5** (1970) 820-2.

Reported a total elongation of 600% on tensile testing at ~0.3 min^{-1} and 400°C, a splat-cooled foil of Al-17 wt% Cu. (QT: 7c, z ~ 50 μm.)

350. H. S. CHEN, H. J. LEAMY, and M. BARMATZ, "The Elastic and Anelastic Behaviour of a Metallic Glass", *J. Non-Crystalline Solids* **5** (1971) 444-8.

Reported dependence on T of internal friction and Young's modulus of glassy and crystalline Pd-7.5 at.% Au-16.5 at.% Si (QT: 9a), determined by a resonance method. Annealing the phase increased the activation energy for the relaxation process from 50 to 80 kcal mol^{-1}, crystallization increasing Young's Modulus by ~ 28%. See also [385a].

351. H. S. CHEN and T. T. WANG, "Mechanical Properties of Metallic Glasses of Pd-Si Based Alloys", *J. Appl. Phys.* **41** (1970) 5338-9.

Reported dependence on concentration of Young's modulus and ultimate tensile strength of AS binary Pd-16 to 20 at.% Si and of AS Pd-16.5 at.% Si with ternary additions of 2 to 12 at.% Au, Ag or Cu. (QT: 9a.)

352. P. ESSLINGER, "Properties of Al alloys after Very Rapid Solidification. II. Mechanical Properties", *Z. Metallk.* **57** (1966) 109-13 (in German). See *Metall. Abs.* **2** (1967) 670.

Extended version of [353].

353. P. ESSLINGER and W. WOLF, "Heat Resistant Metallic Materials by Rapid Cooling from the Melt", *Z. Wirtschaft. Fertigung* **60** (1965) 449-52 (in German).

Reported hardness as a function of cast thickness, time at 200°C and Si content for chill cast Al-2.5 or 5 wt% Cr-up to 10 wt % Si, and tensile strength as a function of test T compared with conventional Al alloys, for Al-6 and 9 wt% Mn, Al-5 wt% Cr, Al-11.9 wt% Si, and Al-8 wt% Fe (with and without 3 wt% Mn). (QT: 7a.) See also [57, 352].

354. N. J. GRANT, "Structure and Property Control through Rapid Quenching of Liquid Metals and Alloys", *Fizika* **2** Suppl. 2 (1970) 16.1-16.15.

Reported TSSE of Pd, Cu, Mn, Fe, Co and Ni in Al, of Zr in Cu and in Al alloy 2024, showing enhanced fatigue and tensile properties for 2024 alloy derived from splat-cooled material. Also reported enhanced mechanical properties in other commercial alloys fabricated from atomized powder. For Abstracts of earlier work see *Scient. Tech. Aerospace Repts.* **5** (1967) No. 9, 1462, No. 21, 3867; *World Alum. Abstr.* **4** (1971 No. 8) 54-0076.

355. H. JONES, "Observations on a Structural Transition in Al Alloys Hardened by Rapid Solidification", *Mater. Sci. Eng.* **5** (1969) 1-18.

Reported optical metallographic, XRD, TEM and microhardness results mainly for Al up to 23.9 wt% Fe. (QT: 1a and 11a, c.) Two zones of microstructure A and B containing metastable $FeAl_6$ were distinguished, the harder one (A) having a hardness of 250 kg mm^{-2} for Al-8 wt% Fe not decreasing detectably in up to 450 h at 200°C. See also 2nd Eur. Symp. on Powder Metallurgy, Stuttgart, 1968, **3** pp. 34-39.

356. A. R. KAUFMANN, "Some Properties of Splat Cooled B-1900", *J. Metals* **20** No. 8 (1968) 109A. Abstract only.

Reported tensile properties and thermal stability of B1900 (Ni-22 wt% Cr-6 wt% Al-3 wt% Th) double-extruded from flake made by splat cooling on to a rapidly moving stainless steel sheet. Inadequate high T strength in relation to conventional

B1900 was attributed to small grain size which gave superplastic behaviour at 1650°F.

357. A. R. KAUFMANN and W. C. MULLER, "Development of U-Base Alloys Strengthened by SLIS Techniques", Report NMI-1262, December 1964. See *Chem. Abs.* **67** (1967) 35762, *Metall. Abs.* **1** (1966) 35, *Nucl. Sci. Abs.* **19** (1965) 32683.

Reported studies of hot compacted and extruded *U*-Be, *U*-C, *U*-Be-C and *U*-Al-Si alloys made by splat cooling on to a rotating disc. (QT: 3c.) Additions of Be were found to be more effective than those of C in increasing strength developed by ageing at 600°C.

358. A. R. KAUFMANN and W. C. MULLER, "Development of Zr-Base Alloys Strengthened by SLIS Techniques", Report NMI-1263, January 1965. See *Chem. Abs.* **66** (1967) 78995k; *Metall. Abs.* **1** (1966) 130; *Nucl. Sci. Abs.* **19** (1965) 34654.

Reported studies of hot compacted and extruded Zr-0.8 wt % Be and Zircaloy 2 -0.68 wt % Be made by splat cooling on to a rotating disc (QT: 3c), resulting in more than doubling the ultimate tensile strength at room temperature and at 600°C, compared with unalloyed Zr and Zircaloy 2 respectively.

359. A. R. KAUFMANN, W. C. MULLER, and R. B. RUSSELL, "Study of Dispersion Strengthened Alloys Produced by SLIS Techniques", U.S. Rept. Comm. Rept. AD634-384, June 1966. See *Chem. Abs.* **66** (1967) 88131g.

Reported studies of dispersed phase coarsening at high *T* in alloys of Ni with Mg, U, Y, La, Gd and Er made by splat cooling. (QT: 3c.) Compounds formed by La and Er showed outstanding stability, comparable with Al_2O_3, up to 1150°C.

360. H. KELLERER and B. LOOMAN, "On the Feasibility of Producing Al-Al_2O_3 Dispersion Hardened Materials by Plasma Spraying", *Metall.* **22** (1968) 212-15 (in German). See *Metals Abs.* **1** No. 6 (1968) 58-0324.

Reported microstructure and hardness of Al-Al_2O_3 dispersion-hardened alloys made by plasma jet spraying (QT: 1b) on to flat and rotating drum substrates. The hardness decreased for 55 kg mm^{-2} at 100°C to 10 kg mm^{-2} at 500°C.

361. G. D. LAWRENCE and G. S. FOERSTER, "Dispersion-Hardened Metals Made by Atom-Quenching", *Internat. J. Powder Metall.* **6** No. 4 (1970) 45-51.

Reported tensile properties at room and elevated *T* for Al, Al-2.5 wt % Mo, Al-10 wt % Cr and Cu-2.3 wt % Ti-0.5 wt % B compacted and extruded from flake made by quenching the melt. (QT: 3c.) The Al-Cr alloy was stronger than SAP up to at least 600°F (314°C) and the splat-cooled Cu alloy was stronger at 1000°F than the same alloy made from cast material.

362. T. MASUMOTO and R. MADDIN, "The Mechanical Properties of Pd-20 at. % Si Alloy Quenched from the Liquid State", *Acta Metall.* **19** (1971) 725-41. See also Abstract in *Fizika* **2** Suppl. 2 (1970) 40.

Reported and discussed the effect of strain-rate, *T* and annealing on elastic and plastic tensile properties of AS Pd-20 at. % Si alloy. (QT: 3f.) Crystallization on annealing was studied by XRD, TEM and resistivity techniques.

363. D. MERZ, "Corrosion Behaviour of Heat-Resistant Al-Alloys in Apparatus for the Desalination of Sea-Water", in *Interocean* '70, Vol. II (VDI-Verlag, Dusseldorf, 1971) pp. 337-9 (in German).

Reported and compared with other alloys, the dependence on d*T*/d*t* of microstructure and dendrite arm spacing, hot strength as a function of test *T* and preparation method, and corrosion potential as a function of exposure time in sea-water, for Al-8 wt % Fe made by casting and by splat cooling. See also [51, 346].

364. M. MOSS, "Dispersion Hardening in Al-V by Plasma-Jet Spray-Quenching", *Acta Metallurgica* **16** (1968) 321-6.

Reported TEM studies and hardness after isochronal annealing up to 550°C for Al-1.1 at. % V dispersion hardened with $Al_{11}V$, made by plasma-spraying. (QT: 1b.) Samples cold-worked to a hardness of 60 kg mm^{-2} retained this for at least 1 h up to 550°C.

365. M. MOSS and D. M. SCHUSTER, "Mechanical Properties of Dispersion-Strengthened Spray-Quenched Al-V Alloys", *Trans. Amer. Soc. Metals* **62** (1969) 201-5.

Reported tensile properties at test *T* up to 480°C and microstructure of hot-pressed plasma-sprayed Al-2.6 and 4.9 wt % V (QT: 1b), obtaining improved resistance to recrystallization at high *T*.

366. D. ROČAK, A. BONEFAČIĆ, and M. PAIĆ, "Microhardness of Rapidly Quenched Al and Al-0.67 at. % Fe Alloys", *Fizika* **2** Suppl. 2 (1970) 21.1-21.4.

Reported, and compared with XRD and TEM results, the effect of isochronal and isothermal annealing on microhardness of Al-0.67 at. % Fe extended solid solution and Al quenched from the melt.

367. D. M. SCHUSTER and M. MOSS, "Dispersion-Strengthened Al-Al_2O_3 by Plasma Spraying", *J. Metals* **20** (1968) 63-6.

Reported microstructure, mechanical properties and stability of Al-1.2 wt % Al_2O_3 made by plasma spraying. (QT: 1b.)

368. G. THURSFIELD, H. JONES, M. H. BURDEN, R. C. DIBLING, and M. J. STOWELL, "Elevated Temperature Mechanical Properties of a Rapidly Quenched Al-8 wt % Fe Alloy", *Fizika* **2** Suppl. 2 (1970) 19.1-19.6. Discussion 19.6.

Reported, and compared with existing Al alloys, tensile properties at test T up to 450°C for Al-8 wt % Fe compacted and extruded from flake made by splat cooling. (QT: 3g, 4c.)

369. T. TODA and R. MADDIN, "The Mechanical Properties of Splat Cooled Al-Base Au Alloys", *Trans. Met. Soc. AIME* **245** (1969) 1045-54.

Reported XRD, TEM and tensile property studies of extended solid solutions of 0.25 to 5 wt % Au in Al (QT: 2b) and the effect of ageing. The yield strength of splat cooled Al-5 wt % Au ($z < 50$ μm) was six times that of the ordinary material.

370. A. TONEJC, D. ROČAK, and A. BONEFAČIĆ, "Mechanical and Structural Properties of Al-Ni Alloys Rapidly Quenched from the Melt", *Acta Metallurgica* **19** (1971) 311-6.

Reported XRD and microhardness studies of Al-up to 11 at.% Ni quenched from the melt and the effect of annealing up to 500°C. TSSE was obtained up to 7.7 at.% Ni and a transitional phase was detected during their decomposition on annealing.

371. A. TONEJC, D. ROČAK, and A. BONEFAČIĆ, "X-ray and Microhardness Investigations of Rapidly Quenched Al-Rich Al-Ni Alloys", *Fizika* **2** Suppl. 2 (1970) 7.1-7.5. Discussion 7.5-7.6.

See [370].

372. D. WEAIRE, M. F. ASHBY, J. LOGAN, and M. J. WEINS, "On the Use of Pair Potentials to Calculate the Properties of Amorphous Metals", *Acta Metallurgica* **19** (1971) 779-88.

Reported calculations accounting for the small density difference (~2%), larger difference in bulk moduli (~7%) and still large difference in shear moduli (29 to 58%) observed experimentally for AS metals, including AS Pd-20 at. % Si made by quenching the melt.

3.7.C. Practical applications

[See also references 363, A2, A50, A63, A65a]

373. T. ARAI and N. KOMATSU, "Heat Treatment Characteristics (I) and Structure (II) of Rapidly Solidified Tool (I) and Cr Die (II) Steels", *Tetsu-to-Hogane* **56** (1970) lectures 261 and 262 (in Japanese). See Brutcher Translation HB 8470 (1971).

Included studies of structure and hardness of steels quenched between copper plates or electron beam melted. See also [A2 and A50].

374. A. R. BOOTH and J. A. CHARLES, "Liquid Phase Equilibria in the Fe-Mn-S-O System and the Effects of Cu and Sn", *Iron and Steel* **42** No. 5 (1969) 298-302.

Investigated two phase region of liquid immiscibility in the Fe-Mn-S-O system in specimens quenched from this condition (QT: 6d), in relation to the production of free-cutting steels.

375. T. F. BOWER, S. N. SINGH, and M. C. FLEMINGS, "Development of High Strength Wrought Al Base Alloys", *Metall. Trans.* **1** (1970) 191-7.

Employed splat cooling (QT: 6g) to monitor suitability for further investigation for development of individual *Al*-Zn-Mg-Cu alloys.

376. D. B. CARYLL and R. G. WARD, "Study of Slag-Metal Equilibria by Levitation Melting: Application to the Fe-Mn-O System", *J. Iron Steel Inst.* **205** (1967) 28-31.

Determined equilibrium distribution of Mn between slag and liquid metal in samples quenched from 1650 to 1870°C by a device for quenching the melt (QT: 5a).

377. R. C. DORWARD, "Splat-Cooled Materials for Neutron Activation Analysis Standards", *J. Nucl. Mater.* **27** (1968) 235-6.

Reported preparation by splat cooling (QT: 5a) of homogeneous specimens of Al-1 wt % Cu and Al-0.5 wt % Au as standards for neutron activation analysis.

378. J. I. GOLDSTEIN, F. J. MAJESKE, and H. YAKOWITZ, "Preparation of Electron Proble Microanalyser Standards using a Rapid Quench Method", in *Advances in X-ray Analysis*, Vol. 10, Ed. J. B. Newkirk and G. P. Mallett (Plenum Press, New York, 1967) pp. 431-45. Discussion pp. 445-6.

Reported preparation by quenching the melt (QT: 3d) and use as microprobe analyses standards of *Au*-Si, *Al*-Mg, *Al*-Cu and *Fe*-Ni alloys.

379. C. JANSEN, B. C. GIESSEN, and N. J. GRANT, "Atmospheric Corrosion of Splat-Cooled Al Alloy Foils", *J. Metals* **20** No. 12 (1968) 10-11.

Reported correlation between atmospheric SO_2 concentration and weight change of exposed splat-cooled foils of Al and Al up to 5 wt % Ni, Co, Fe, Mn and Pd.

380. C. C. TSUEI and P. DUWEZ, "Radiation-Insensitive Amorphous Alloy Resistance Thermometer for Low Temperature", *J. Phys. E: Sci. Instrum.* **4** (1971) 466-7.

Reported characteristics of AS Pd-7 at. % Cr-20 at. % Si (QT: 6b) for use as a radiation-insensitive high-sensitivity thermometer for use up to 500 K.

381. T. T. WANG, H. S. CHEN, and T. K. KWEI, "A Tough and Transparent Polyethylene", *Polymer Letters* **B8** (1970) 505-10.

Reported use of twin-roll quenching device (QT: 9a) to make thin polyethylene sheets from the melt, with improved transparency and mechanical properties.

382. R. H. WILLENS, "A New Method of Preparing Samples for Transmission Electron Microscopy", Proc. 5th Internat. Congr. on Electron Microscopy 1962, Paper EE-6.

Reported use and microstructure of Au, Ag-39.9

at.% Cu and Ag-25 at.% Ge foils for TEM, prepared by splat cooling.

383. R. H. WILLENS, E. BUEHLER, and E. A. NESBITT, "Inductance Thermometer", *Rev. Sci. Instrum.* **39** (1968) 194-6.

Reported use of splat-cooled Co-12 wt % Cr-36 wt % Fe as an inductor incorporated into an oscillator to generate a frequency which depended on *T*, allowing very accurate measurements of *T* between 1 K and room temperature.

3.8. Addendum for 1958-71

384. E. BABIĆ, E. GIRT, R. KRSNIK, B. LEONTIĆ, and I. ZORIĆ, "Vacancy Resistivity Dependence on Lattice Parameter Change in Pure Rapidly Quenched Al Samples", *Fizika* **2** Suppl. 2 (1970) 30.1-30.4. Discussion 30.5.

Essentially as [52].

385. E. BABIĆ, R. KRSNIK, B. LEONTIĆ, and I. ZORIĆ, "Measurement of Residual Resistivity of Rapidly Quenched Samples of Al-Fe Alloy", *Fizika* **2** Suppl. 2 (1970) 28.1-28.4. Discussion 28.4.

Slight extension of results of [96] showing that no further increase in residual resistance ratio occurs at Fe contents exceeding 0.7 at.% Fe which thus appeared to be the limit of true extended terminal solid solubility for the experimental conditions, including twin-roll method (QT: 9b.)

385a. M. BARMATZ, H. J. LEAMY, and H. S. CHEN, "A Method for the Determination of Young's Modulus and Internal Friction in Metallic Glasses", *Rev. Sci. Instr.* **42** (1971) 885-6.

Described resonance method for determining *T*-dependence of Young's Modulus and internal friction for ribbon samples. Quoted results for Pd-7.5 at.% Au-16.5 at.% Si quenched from the melt (QT: 9a, $z = 54$ μm, dT/dt 4×10^5 K sec^{-1}). See also [350].

385b. M. CHYUCZEWSKI and H. MATYJA, "A Device for Very Rapid Cooling of Metals from the Liquid State", Report Inst. Nucl. Research, Warsaw, 1971 (1343/XIV/PS) 11 pp. (in Polish). See *Metals Abs.* **5** No. 12 (1972) 56-0418.

Described apparatus for splat cooling employing pressure expulsion of melt through a crucible orifice on to an inclined substrate (QT: 1k, $z = 0.1$ to 5 μm).

386. V. N. FILIMONENKO, J. GURLAND, and M. H. RICHMAN, "The Microstructure of Electric Discharge Machined WC-Co", *Metallography* **2** (1969) 125-36.

Reported formation of fcc form of WC, as well as W_2C, in addition to hexagonal WC in electrical discharged machined surfaces of sintered WC-Co alloys, and the effect of discharge capacitance and of annealing. See also [200, 201], *Chem. Abs.* **70** (1969) 6173a, 6212n and Proc. 26th EMSA (Electron Microscopy Society of America) Meeting.

387. B. JOUFFREY, A. DANIEL, and B. ESCAIG, "Intersections of Stacking Faults", *J. de Physique* **27** Suppl. C3 (1966) 114-20 (in French). See *Chem. Abs.* **66** (1967) 88019j.

Reported TEM observation of stacking fault intersections in Al-30 wt% Ag quenched from the melt and in Co-18.4% Cr. See also Proc. 6th Internat. Congr. for Electron Microscopy, Kyoto 1966, Vol. I, pp. 81-2.

388. S. K. KHERA and P. K. K. NAYAR, "Phase Changes in Splat-Cooled Sb-Sn Alloys", Proc. Symp. on Materials Science Research in India, 1970, Vol. II (Bhabha Atomic Research Centre, Bombay, 1971) pp. 345-51. From *Metals Abs.* **4** No. 12 (1971) 12-1785.

Reported XRD, electron microprobe and resistivity studies of Sn up to 25.7 wt % Sb quenched from the melt. A new tetragonal phase, with double the unit cell of Sn, was found.

389. D. LESUEUR, J. Y. THOMAS, and V. VENDITTI, "The Dependence of the Linear Expansion Coefficient on Applied Stress in an Amorphous Metallic Alloy", *Revue Phys. Appl.* **6** (1971) 91-4 (in French). See *Metals Abs.* **6** No. 2 (1973) 32-0148.

Described apparatus for measuring thermal expansion coefficient and thermoelastic modulus at elevated temperatures. Values for AS Pd-20 at. % Si made by quenching the melt were more typical of a crystalline than of a liquid alloy. ($z = 20$ μm.)

389a. H-L. LUO, "Superconducting Metastable Phases in T2-Au Alloys", Abstract Bull. of Inst. Met. Div. of AIME, **2** No. 1 p. 44 for 96th Annual Meeting, Los Angeles, Feb. 1967.

Reported formation of two superconducting MCS phases in Tl-Au alloys quenched from the melt. Bcc β-Til was partially retained by alloying with <20 at. % Au.

390. L. I. MIRKIN, "Saturation of Fe with W during action of a Laser Light Beam", *Izv. VUZ Chernaya Met.* **14** No. 2 (1971) 98-101 (in Russian). See *Chem. Abs.* **75** (1971) 26286w.

Reported TSSE of up to 15 to 18% W in Fe by rapid cooling of molten Fe-W solutions formed by action of laser beam on W powder on a Fe surface.

391. I. S. MIROSHNICHENKO, G. A. SERGEEV, and I. M. GALUSHKO, "Metastable Diagrams in the Ni-C and Co-C systems", in *Diagrammy Sostoyaniya Metal Sistem*, "Nauka" Moscow 1971 pp. 164-6 (in Russian). See *Metals Abs.* **5** No. 9 (1972) 11-0655.

Reported conditions for formation of metastable rhombohedral Co_3C and hexagonal Ni_3C by quenching Co-C and Ni-C melts at 10^5 to 10^6 K sec^{-1}, and the microstructure and microhardness of their eutectics with Co and Ni.

392. R. MISHIMA, Y. ISHIDA, and M. KATO, "Mössbauer Analysis of the Ageing Process in Splat-Cooled Al-Fe Alloys", *Seisan-Kenkyu* **23** No. 2 (1971) 85-7 (in Japanese). See *Chem. Abs.* **74** (1971) 145496d.

Reported single peak in Mössbauer spectrum of a quenched and rolled *Al*-Fe alloy solid solution. An additional peak due to Fe in ordered $FeAl_3$ occurred on ageing at 300 or 410°C. A splat-cooled alloy showed three peaks decreasing to two and one when annealed at 250°C and >350°C respectively.

393. R. MISHIMA, Y. ISHIDA, and M. KATO, "Electron Microscope Structure of Splat-Cooled Al-Fe Alloy", *Seisan-Kenkyu* **23** No. 3 (1971) 117-8 (in Japanese). See *Chem. Abs.* **75** (1971) 8865e.

Discussed electron micrographs showing microstructure of splat-cooled Al-2% Fe.

394. R. MISHIMA, Y. ISHIDA, and M. KATO, "Structures of Splat-Cooled Al-Fe Alloys. II", *Seisan-Kenkyu* **23** No. 5 (1971) 207-8 (in Japanese). See *Chem. Abs.* **75** (1971) 66821y.

Extension of [393].

395. H. MIYAJIMA and S. IIDA, "Rapid Quenching Drop Smasher Operative at Liquid Nitrogen Temperature", *Japan. J. Appl. Phys.* **10** (1971) 1471 only.

Described modified version of piston-and-anvil apparatus of Harbur *et al* [42] allowing substrate to be held at any T between 140 and 330 K. (QT: 6e.)

396. M. OHRING and A. HALDIPUR, "A Versatile Arc-Melting Apparatus for Quenching Molten Metals and Ceramics", *Rev. Sci. Instrum.* **42** (1971) 530-1.

Described piston-and-anvil device based on an arc furnace. Piston or hammer on an arrow shaft is propelled by releasing tension springs. (QT: 6j.) cf. [38].

397. A. F. POLESYA and A. I. STEPINA, "Structure of Molten Alloys Cooled Rapidly from the Molten State", *Izv. VUZ Tsvet. Met.* **13** No. 5 (1970) 122-5 (in Russian). See *Chem. Abs.* **74** (1971) 116812y, *Metals Abs.* **4** No. 5 (1971) 12-0636.

Reported variations in thickness and microstructure in Al-2.9 to 4.5 wt% Cr, Al-3 to 7.5 wt% W and Al-3 to 4 wt% Mn. (QT: 3a, $z \sim 100$ to 200 μm.)

398. I. V. SALLI, "Crystallization at Superhigh Cooling Rates", *Visn. Akad. Nauk Ukr. RSR* 1971 No. 5 32-41 (in Ukrainian). See *Chem. Abs.* **75** (1971) 79581v.

Tabulated and discussed data on the effect of solidification at high dT/dt on the structure and properties (physical, mechanical and electrical) for 75 binary alloys (16 references).

399. I. V. SALLI, V. A. DZENZERSKY, V. S. SHVETS, and T. YA. ERINA, "Method of Studying the Structure and Properties of Alloys Solidified of Extremely High Cooling Rates", *Akad. Nauk Ukrain. SSR Metallofizika*, **1971** No. 33 pp. 59-61 (in Russian). See *Metals Abs.* **5** No. 5 (1972) 22-0334.

Reported formation of metastable intermediate phases, depending on dT/dt, in Sn-26 to 80 at. % Pb alloys, rapidly solidified at high dT/dt on substrates at liquid N_2 temperatures.

400. A. K. SINHA, "Temperature and Field Dependence of Magnetization of Amorphous (Fe, Mn)-P-C Alloys", *J. Appl. Phys.* **42** (1971) 338-42.

Reported and discussed dependence on T, applied field and composition of the magnetization of AS $(Fe_{1-x}Mn_x)_{0.75}P_{0.15}C_{0.10}$, where $0.0 \leqslant x \leqslant 1.0$, quenched from the melt by a piston-and-anvil method. ($z \sim 40$ μm, dT/dt up to 10^6 K sec^{-1}.)

401. S. SRINAVASA RAO, C. SURYANARAYANA, and T. R. ANANTHARAMAN, "Metallographic and X-ray Studies of Phase Transformations in α-β Brasses", *Indian J. Technol.* **9** (1971) 11-18.

Reported study of phase formation by both solid state quenching and splat-cooling (QT: 1j, $z \sim 15$ μm) in Cu-37.0 to 42.0% Zn, including the formation of a metastable cph Hume-Rothery phase. See also [220].

401a. T. TAKAMORI and R. ROY, "Crystallization Temperature—A New Parameter to Characterize Noncrystalline Oxide Materials", in *Advances in Nucleation and Crystallization in Glass*, Ed. L. L. Hench and S. W. Frieman (Amer. Ceram. Soc., Columbus, Ohio, 1972) pp. 173-82.

Reported composition-dependence of crystallization T for several binary oxide glass systems for specimens made by splat cooling or flame spraying.

402. J. ZBORIL and Z. POSEDEL, "Microstructure and Hardness of Fe-Mo-C and Fe-Ti-C after Rapid Cooling from the Melt", *Z. Metallk.* **61** 1970) 214-17 (in German). See *Chem. Abs.* **72** (1970) 124235m.

Reported suppression of MoC formation in Fe-Mo-C Cooled from the melt at $>10^3$ K sec^{-1} and increased hardness of Fe-Ti-C alloy with increasing dT/dt from the melt. Alloys were melted in a plasma arc under Ar and cooled by impact spreading between water-cooled Cu substrates. (cf. QT: 5b, 6c and 6j.)

TABLE 1a Single substrate methods (QT: 1 to 4) of rapid quenching from the liquid to the solid state

Designation	Heating	Melt container	Melting atmosphere	Melt mass	Drive to substrate	Substrate conditions	Splat thickness z	Cooling rate dT/dt	Alloys tested	References
1. Gun										
a	RF (to 1000° C)	Graphite†	Argon	~100 mg	Shock tube, 0.003 in. mylar, 700 psi He	Copper ski-slide*	<0.1 to some µm	>2 × 10^6 K sec^{-1} [5, 89]	Ag-Cu, Ag-Ge etc.	Duwez *et al* [26, 105]. See also [14, 388]
b	Plasma gun					Copper plate			Ag-Cu, Ag-Ge, Mo-Ru	Moss *et al* [205]
c	Arc	Hearth	Helium or argon	0.5 to 1 g	Nozzle, 1000 psi argon	Copper shield or [320] plate in [266] argon	10 to 20 µm [266] 50 to 200 µm [329]	>10^5 K sec^{-1} [329]	Nb_3Ge	Matthias *et al* [324]
d	Resistance (to 1000° C)	Graphite	Air	<1 g	Explosive charge. Substrate impact at 1000 ft/sec^{-1}	Copper ski-slide with Ni/Ag insert	~1 µm	10^6 to 5 × 10^8 K sec^{-1}	Ag, Al, Bi, Au-Sb	Predecki *et al* [49]
e	RF concentrator (to >3900° C)	Silver hearth	Argon	~100 mg	Shock tube, 0.003 in. mylar, 1000 psi He	Copper ski-slide			Refr. carbides, aluminides	Willens and Buehler [39]
f	Strip heater	Heater			Shock tube, burst disc 80 psi air, impact 700 ft sec^{-1}	Transverse glass slide			Refractory oxides	Sarjeant and Roy [250] See also [A64]
g	Resistance	Alumina	Vac./contr. atm.		Shock tube, mylar diaphragm	Copper ski-slide* in vac./contr. atm.			Al-Au, Al-Cu	Shingu *et al* [293]
h	Graphite cloth (to 1650° C)	Alumina	CO/argon	5 to 50 mg	Shock tube, polythene disc, 1200 psi He	Transverse copper in CO/argon	~10 µm		Fe-C, Fe-C-Si etc.	Ruhl and Cohen [149]
	RF	Graphite or alumina	Vac. 10^{-5} Torr	60 mg	Shock tube, 1.2 mm orifice	Copper plate in vac. 10^{-5} Torr	~50 µm	up to 10^5 K sec^{-1}	Cu, Cu-Ni	Löhberg and Müller [45]
	Kanthal resistance	Graphite	Vac. or inert gas	~0.5 g	Shock tube, burst mylar, ~0.4 kg mm^{-2} Ar, 1 mm orifice	Copper ski-slide in vac. or contr. atm.	<10 µm	~2 × 10^6 K sec^{-1} [220]	Ag, Ag-Ge	Ramachandrarao *et al* [82]. See also [A35]*
k	Resistance or RF (1000 to 1600° C)				Ar at 16 atm, crucible orifice	Inclined at 15 to 25°.	*0.1 to 5 µm			Chyuczewski and Matyja [385b]
2. Catapult										
a						Copper sheet	200 to 300 µm	5 × 10^4 K sec^{-1}	Al-Mn, Al-Cr	Varich and Kolesnichenko [164]
b	Nichrome resistance	Graphite or BN	Nitrogen		Steel torsion bar released	Copper ski-slide* in nitrogen	40 to 60 µm		Al base alloys	Roberge and Herman [35]
3. Rotating substrate										
a	RF [197]	Graphite	Air [197]	~25 mg	Shock tube, helium driven	Inside rotating copper cylinder	~15 µm [197]		Ag-Cu etc.	Duwez *et al* [26, 105]
b	Graphite		Reducing	0.25 to 0.5 g	Lever and spring	Inside 8000 rpm copper cylinder		~4.5 × 10^6 K sec^{-1}	Al-Mn, Pb-Cu	Salli and Limina [36]
c	RF (to 1900° C)	Graphite	Vac. or argon		Gas-blast atomization	1700 rpm Cr-plated Cu disc in vac. or Ar			U, Zr and Ni alloys	Kaufmann *et al* [357-9] See also [356, 361]
d	RF	Boron nitride	Argon		Argon pressure	Hemispherical up to 2000 rpm hearth in air			Au-Si, Al-Mg	Goldstein *et al* [378]
e	RF		Purgon		Purgon pressure	Inside 15 000 rpm copper cone in purgon	>0.1 µm		Ag-Cu	Stoering and Conrad [157]
f	Tube furnace	Graphite			Gas pressure	Inside rotating cup	Filaments, 5 to 50 µm		Al, Ag-Cu, Pb-Sn	Pond and Maddin [33]
g	RF	Graphite	Argon	kg	Argon blast atomization	Outside, up to 300 rpm, Cu drum in Ar	~30 µm		Al-Fe	Thursfield and Jones [37]
h					Gas pressure	Rotating chill block	2 to 250 µm	10^5 to 10^8 K sec^{-1}	7075 Al	Mobley *et al* [A30]
i					Melt off rod	Rotating Cu disc	100 to 200 µm		Nb-2% Al_2O_3.	Revyakin *et al* [A61a]
4. Rotating melt										
a	Arc	Rotating sample electrode	Helium		Centrifugal pressure	Rotating copper plate in helium	5 to 10 µm		Be	Kaufmann and Muller [63]
b		Graphite, 1400 rpm			Centrifugal pressure	Inside surrounding copper drum	150 to 200 µm		Al, Sb	Kumar and Sinha [66]
c	Resistance (to 1100° C)	Graphite, to 2 × 10^4 rpm	Argon	1000 g	Centrifugal pressure	Inside surrounding copper drum in argon	Layer flake		Al-Fe	Jones and Burden [29]
d	RF (to ~1000° C)	10^3 to 1.4 × 10^4 rpm		15 kg	Centrifugal pressure	Inclined steel or copper plates	Layer flake		Al-Fe	Ahlborn and Merz [51]

*Substrate cooling available e.g. to liquid nitrogen temperature
†Ceramic insert could be fitted.

TABLE 1b Twin substrate methods (QT: 5 to 10) of rapid quenching from the liquid to the solid state

Designation	Heating	Melt container	Melting atmosphere	Melt mass	Melt release	Drive to substrate	Substrate conditions	Substrate synchronization	Substrate drive	Splat thickness (z)	Cooling rate (dT/dt)	Alloys tested	References
5. Hammer and anvil													
a	RF	Levitation	Helium	>0.7 g	RF off	Gravity	Steel piston, copper hammer in He	With RF off	Lead pendulum	~100 µm	10^5 K sec^{-1}	Fe-Mn-O	Caryll and Ward [376]. See also [A5]
b	Arc (to 2000° C)	Copper hearth		0.3 to 0.5 g	Not needed	Remains on hearth	Cu-capped hammer, Cu anvil in Ar	Not needed	Falling hammer	~40 µm	up to 10^5 K sec^{-1}	Ag-Ge	Wang [38]. See also [402]
6. Piston and anvil													
a	Resistance	Magnesite			Catch	Lever and spring		Time delay	Solenoid	~100 µm		Al-Mn, Fe-C, Ni-C	Miroshnichenko and Salli [31]
b	Gas flame	Graphite				Gravity	Copper	Trip and solenoid	Fluid	~44 µm [235]		Cu-Ag, Ag-Ge	Pietrokowsky [32]
c	Electron beam	Copper plate	Vacuum		Not needed	Swept by piston	Copper* in vacuum	Not needed	Solenoid			Pd-Si, boron	Galasso and Vaslet [27]. See also [402]
d	RF (>1600° C)	Levitation	Contr. atm.		RF off	Gravity	Copper	Time delay	Solenoid	150 µm [374]	~10^6 K sec^{-1} [374]	Fe-base	Booth and Charles [24]
e	RF	Melt off rod sample	Vac. or atm.		Melting	Gravity	Cu, Al etc, closure speed 12 ft sec^{-1}, in. vac. or atm.	Photocell	Solenoid	44, 70 µm	10^5 to 10^6 K sec^{-1}	Pb, Pb-Sn, Al, Ag-Cu	Harbur *et al* [42]. See also [395]
f	RF	Levitation	Inert gas		RF off	Gravity	Stainless steel in inert gas	Falling weight	Fluid	~25 µm		Ag-Ge	Baker *et al* [23]
g	RF	Levitation	Argon	~2 g	RF off	Gravity	Copper	Photocell	Solenoid	~130 µm	10^5 to 10^6 K sec^{-1}	Al (and Fe) base	Bower *et al* [375]. See also [55] and [A34]
h	Kanthal resistance	Graphite	Vac. or inert gas	~0.5 g	Shock tube	As QT : 1j	Copper	Pressure switch	Spring	20, 70 µm		Pb, Ag-Ge, Cu-Ag	Ramachandrarao *et al* [34]
i	Resistance	Graphite	Vac. or inert gas	50 to 150 mg		Gravity	Copper* in vac. or inert gas	Photocell	Solenoid	5 to 60 µm		Cd [67]	Laine *et al* [30]
j	Arc	Copper hearth		100 s mg	Not needed	Arrow release	Al, impact speed ~23 m sec^{-1}	Not needed	Spring	10 to 100 µm	~5×10^5 K sec^{-1}	V_2O_5	Ohring and Haldipur [396]
7. Two-piston													
a	RF	Levitation		~10 g	RF off	Gravity	Copper in air	Photocell	Magnetic	100 to 300 µm		Al base alloys	Esslinger and Wolf [353]
b	W filament	Alumina	Vacuum	50 to 100 mg	Burst disc 60 kg cm^{-2}	Argon gas	Steel, closure speed 10 to 20 m sec^{-1}, in vacuum	Same drive circuit	Argon gas	Few to 100s µm		Al-Ag, Au-Si	Dixmier and Guinier [104]
c	RF	Levitation	Vac. or inert gas	~400 mg	RF off	Gravity	Copper in vac. or inert gas	Photocell	Solenoid	70 to 80 µg	~10^6 K sec^{-1}	Al base alloys	Beghi *et al* [54, 348]
d	Resistance	Graphite or alundum	Reducing			Push-rod	Copper	Not needed	Solenoid	~130 µm	~10^5 K sec^{-1}	Al-Cr	Miroshnichenko and Zakharov [48]
8. Roller and discs	Tamman furnace					Furnace arm	2500 rpm discs, one bent against roller		Motor		~10^6 K sec^{-1}		Salli and Limina [36]
9. Twin-roll													
a	RF	Levitation		<1 g	RF off	Gravity	100 to 5000 rpm steel rollers			10 to 100 µm	~10^5 K sec^{-1}	Pd-Si, Te-Ge etc.	Chen and Miller [25]
b	Nichrome resistance	Alumina	Helium		He gas blast	4 to 6 atm. He	3000 rpm brass, 7000 to 10^4 rpm steel—rollers in He	With melt ejection speed	Motor	7 to 15 µm	10^6 to 10^7 K sec^{-1}	Al-Fe	Babić *et al* [21, 22]
10. Injection mould			Argon		Melt Al foil seal in sample melt	Ar pressure	Cylindrical Cu mould in Ar	Not applicable	Not applicable	<500 µm	~10^4 K sec^{-1}	Al-Mn	Hinesley and Morris [28]

*Substrate cooling available

TABLE Ic Self-substrate methods (QT: 11a-c) of rapid quenching from the liquid to the solid state

Designation	Heat source	Environment	Thickness melted	Cooling rate (dT/dt)	Alloys tested	References
11a	Spark discharge	Air			Ag-Cu	Mutsuzaki *et al* [138]
					Al-Ag, Al-Cu	Kaneko and Ikeuchi [110]
			up to 300 μm	~10^6 K sec^{-1}	Al-Fe	Jones [355]
					WC, Co, WC-Co	Krainer and Robitsch [116, 200-1]
		Kerosene dielectric			WC-Co	Filimonenko *et al* [386]
		Liquid inert gas	100 Å particles		Ni, Cu-Ag etc.	Ruppersberg and Bold [A39]
11b	Electron beam	Vacuum			Al-Si, Al-Mn	Hiller [61], Lux and Hiller [68]
11c	Laser	Air	10 to 60 μm	~10^6 K sec^{-1}	Al-Fe	Jones [355]
			20 to 200 μm		Fe-W, Ag-Ge	Laridjani *et al* [A27]
			up to 330 μm	~3.7×10^6 K sec^{-1}	2024 Al, Ag-Cu	Elliott *et al* [A12]

4. Appendix 1: Author index for 1958-72

5. Appendix 2: Alloy index for 1958-72

Includes references to Review articles [1-20, A14, A20, A49] only when these contain otherwise unpublished material. (The first quoted element is the major alloying constituent.)

6. Appendix 3: Supplement for 1972

A1. T. R. ANANTHARAMAN and C. SURYANARAYANA, Reply to "A Comment on 'A Decade of Quenching from the Melt'" by H. Jones, *J. Mater. Sci.* 7 (1972) 351-3. See [2, A21, A22].

In replying to [A21], TRA and CS accept the applicability of all methods of estimating cooling rate in splat cooling, the suitability of a given method depending on particular circumstances.

A2. T. ARAI and N. KOMATSU, "Determination of Phases in Tool Steels Quenched from the Liquid State", *Tetsu-to-hagane* **58** (1972) 899-920 (in Japanese). See *Metals Abs.* **5** No. 11 (1972) 12-1381 and *Trans. ISI Japan* **12** (1972) 322.

Reported constitutional changes in high speed steel quenched from the melt by several techniques including splat cooling. See also [373, A50].

A3. E. BLANK, "Precipitation of Fe and Annealing-Out of Lattice Defects in Rapidly Solidified Al-Fe alloys I. Structure and Properties of Quenched Samples", *Z. Metallk.* **63** (1972) 315-23 (in German).

Reported TEM, microhardness and resistivity studies of Al up to 2 at. % Fe quenched from the melt. (QT: [A5]). Results were interpreted on the basis of a metastable phase diagram. See also [261, A4, A5].

A4. E. BLANK, "Precipitation of Fe and Annealing-Out of Lattice Defects in Rapidly Solidified Al-Fe Alloys II. Annealing Behaviour", *Z. Metallk.* **63** (1972) 324-31 (in German).

Reported TEM and hardness studies of annealing of Al up to 2 at. % Fe quenched from the melt. (QT: [A5]). The sequence of precipitation from extended solid solution was interpreted by analogy with the archetypical behaviour of Al-Cu supersaturated solid solutions made by solid state quenching. See also [261, A3, A5].

A5. E. BLANK, "Very Fast Cooling of Metal Melts: Construction of a Clap-Type Mould and Solidification of the Melt within it", *Arch. Eisenhüttenwesen* **43** (1972) 649-55 (in German).

Described hammer-and-anvil device for quenching from the melt and considered the formation and solidification of the sample between the hammer and anvil. See also [A3, A4] and *Arch. Eisenhüttenw.* **44** (1973) in press.

A6. B. Y. BOUCHER, "Influence of P on the Electrical Properties of Pd-Ni-P Amorphous Alloys", *J. Non-Cryst. Solids* **7** (1972) 277-84.

Reported composition limits for formation of AS Pd-Ni-P alloys by quenching the melt and measurements of the temperature dependence of resistivity of $(PdNi)_{100-x}P_x$ where $15 < x < 27.5$. See also [A7].

A7. B. Y. BOUCHER, "Electrical Properties of Amorphous $(Pd_{60-x}$-Pt_x-$Ni_{40})_{75}$-P_{25}", *J. Non-Cryst. Solids* **7** (1972) 113-15.

Reported measurements, as a function of Pd content, of the temperature dependence of resistivity of AS $(Pd_{60-x}$-$Pt_xNi_{40})_{75}P_{25}$ made by quenching the melt. See also [A6].

A8. H. S. CHEN and M. GOLDSTEIN, "Anomalous Viscoelastic Behaviour of Metallic Glasses of Pd-Si-Based Alloys", *J. Appl. Phys.* **43** (1972) 1642-8.

Reported and discussed temperature and stress dependence of viscoelastic properties near the glass temperature for AS Pd-4 at. % (Au, Ag or Cu)-16.5 at. % Si. A large activation volume for viscous flow implied a flow mechanism involving co-operative atomic displacements in the direction of flow.

A9. W. Y. K. CHEN and C. C. TSUEI, "Occurrence of Superconductivity in Simple Cubic $(Au_{1-x}Pd_x)$ Te_2 Alloys", *Phys. Rev.* **B5** (1972) 901-3.

Reported and discussed dependence on x of the superconducting transition temperature of MCS simple cubic $(Au_{1-x}Pd_x)$ Te_2 with $0 \leqslant x \leqslant 6$ made by quenching the melt. Transverse magnetoresistance was reported for $x = 0.2$.

A10. E. DARTYGE, M. LAMBERT, G. LEROUX, and A. M. LEVELUT, "Study of the State of Dispersion of Solute in Dilute Solid Solutions of Al", *Acta Metallurgica* **20** (1972) 233-40 (in French). See *Metals Abs.* **5** No. 8 (1972) 12-1018.

Reported low angle XRD studies of solute clustering in Al-Ni and Al-Mn extended solid solutions made by quenching the melt and in Al-Zn supersaturated solid solutions quenched within the solid state. More clustering had occurred in Al-Ni while in all cases it proceeded rapidly above 300° C.

A11. H. A. DAVIES and J. B. HULL, "An Amorphous Phase in a Splat-Quenched Al-17.3 at. % Cu Alloy", *Scripta Metall.* **6** (1972) 241-6.

Reported TEM and selected area diffraction evidence for formation of AS Al-17.3 at. % Cu by quenching the melt, using a gun technique in an inert atmosphere (Ar).

A12. W. A. ELLIOTT, F. P. GAGLIANO, and G. KRAUSS, "Rapid Cooling by Laser Melt Quenching", *Appl. Phys. Letters* **21** (1972) 23-5.

Used Laser method (QT: 11c) to obtain average dT/dt for quenching from the melt of 3.7×10^6 K sec^{-1} for 2024 Al and to obtain TSSE of 49.2 at. % Cu in Ag.

A13. P. FURRER, H. WARLIMONT, and T. R. ANANTHARAMAN, "Electron-Microscopic Examination of a Splat-Cooled Ag-Ge Alloy", *Proc. Indian Acad. Sci.* **75A** (1972) 103-7.

TEM and electron diffraction indicated the existence of long-period structures in a splat-cooled Ag-15 at. % Ge alloy. It is concluded that the structure observed may have formed by martensitic transformation of a metastable bcc phase first formed on solidification.

A14. B. C. GIESSEN and C. N. J. WAGNER, "Structure and Properties of Noncrystalline Metallic Alloys produced by Rapid Quenching of Liquid Alloys", in *Liquid Metals, Chemistry and Physics*, Ed. S. Z. Beer (Marcel Dekker, New York, 1972) pp. 633-95

Comprehensive review of structure, formation and properties (thermal, electronic and mechanical) of AS metallic alloys made by quenching the melt (139 references, to 1971).

A15. B. C. GIESSEN, J. M. VITEK, and N. J. GRANT, "Metastable Phases in the Tl-Sn Alloy System", *Metall. Trans.* **3** (1972) 2449-53.

Reported solid solubility extension and formation of four new MCS phases in Tl-Sn alloys quenched to $-190°C$ from the melt by a gun technique.

A16. S. P. GUPTA, "Martensitic Transformation in Splat-quenched β Ag-Al Alloys", *Mater. Sci. Eng.* **10** (1972) 341-56.

Reported TEM and electron diffraction study of composition dependence, relative stability and microstructural features of three crystallographically distinct martensites in Ag-21 to 23.5 at. % Al quenched from the melt. See also *J. Phys. Soc. Japan* **32** (1972) 1682 only.

A17. R. HASEGAWA, "Spin Fluctuation Resistivity in Alloys", *Physics Letters* **38A** (1972) 5-7.

Interpreted decreased resistivity with increasing *T* of extended Al-Mn solid solutions and AS Ni-Pt-P made by quenching the melt, to give reasonable values for a spin-fluctuation *T*.

A18. R. HASEGAWA, "Electrical and Magnetic Properties of Amorphous Pd-Si Alloys Containing Fe and Cr", *J. Appl. Phys.* **43** (1972) 1231-4.

Reported and discussed measurements of electrical resistivity, magnetization and magnetoresistivity of AS $Fe_xCr_{2-x}Pd_{78}Si_{20}$ ($0 \leqslant x \leqslant 2$) made by quenching the melt. The results account for the large scatter in Kondo *T* and of magnetoresistivity found earlier for AS Cr-Pd-Si alloys containing Fe as an impurity in the Pd.

A19. R. HASEGAWA, "Evidence for the $T^{-\frac{1}{2}}$ Singularity in Kondo Alloys", *Phys. Rev. Letters* **28** (1972) 1376-8.

A $T^{-\frac{1}{2}}$ term found in the resistivity versus *T* relationship for AS Ni-Pd-P-base alloys containing Fe, made by quenching the melt, was attributed to interference between scattering by magnetic, and by non-magnetic, impurities.

A20. H. JONES, "Metastability and Splat Cooling", *J. Sheffield Metallurgical Soc.* **11** (1972) 50-7.

A selective review of a range of splat cooling phenomena (46 references, to 1971).

A21. H. JONES, "A Comment on 'A Decade of Quenching from the Melt'," by T. R. Anantharaman and C. Suryanarayana", *J. Mater. Sci.* **7** (1972) 349-51.

Questioned critical comments in ref. 2 about the eutectic method [40] as against the dendrite method [41, 47] of estimating dT/dt in splat cooling. For reply see [A1] and for further comment see [A22].

A22. H. JONES, "Comments on Author's Reply to 'A Comment on "A Decade of Quenching from the Melt" ' ", *J. Mater. Sci.* **7** (1972) 353-4.

In replying to [A1], underlined the need to cross-check various methods of estimating dT/dt for the same conditions.

A23. H. A. KÄHKÖNEN, "Precipitation in Al-Ag Alloys Quenched from the Liquid State", *Metall. Trans.* **3** (1972) 739-40.

Reported small angle XRD studies of ageing of Al-10 to 50 wt % Ag solid solutions made by quenching the melt. (QT: 6i, substrate *T*, 20°C or $-90°C$.) See also [A55].

A24. L. KAMMERDINER and H-L. LUO, "Superconductivity in the Nb-rich Nb-Al Alloys", *J. Appl. Phys.* **43** (1972) 4728-31.

Reported lattice constants and superconducting transition temperature T_c for annealed Nb-18 to 25.2 at. % Al alloys made by both quenching the melt and sputtering. The highest T_c was 18.6 K for quenched samples at 16.6 K for sputtered samples.

A25. H. O. K. KIRCHNER, P. RAMACHANDRARAO, and G. A. CHADWICK, "Decomposition of the Metastable Phase in the Ag-Ge System", *Phil. Mag.* **25** (1972) 1151-60.

Reported DTA, XRD and TEM studies of the two-stage decomposition on annealing of MCS cph Ag-23 at. % Ge made by quenching the melt.

A26. U. KÖSTER, "Metastable Phases in Rapidly Solidified Al-Ge Alloys", *Z. Metallk.* **63** (1972) 472-9 (in German).

Reported XRD and electron diffraction evidence for formation of three MCS phases in Al-Ge alloys quenched from the melt. These decomposed eutectoidally to Al and Ge equilibrium solid solutions on annealing. See also [276].

A27. M. LARIDJANI, P. RAMACHANDRARAO, and R. W. CAHN, "Metastable Phase Formation in a Laser-Irradiated Ag-Ge Alloy", *J. Mater. Sci.* **7** (1972) 627-30.

Reported XRD and metallographic evidence for formation of MCS cph Ag-21 at. % Ge by laser-melt-quenching.

A28. H. J. LEAMY, H. S. CHEN, and T. T. WANG, "Plastic Flow and Fracture of Metallic Glass', *Metall. Trans.* **3** (1972) 699-708.

Reported tensile flow and fracture behaviour of three Pd-20 at. % Si based alloys in the glassy, microcrystalline and fully crystalline conditions. Results for glassy materials were interpreted in terms of plastic flow via localized strain concentrations and fracture initiated by catastrophic adiabatic shear.

A29. R. MADDIN and T. MASUMOTO, "The Deformation of Amorphous Pd-20 at. % Si", *Mater. Sci. Eng.* **9** (1972) 153-62.

Reported studies of time-dependent mechanical properties of AS Pd-20 at. % Si made by quenching the melt. On this basis, a model was developed for formation in the AS phase of crystalline islands, growing with the application of *T*, stress and time.

A30. C. E. MOBLEY, A. H. CLAUER, and B. A. WILCOX, "Microstructures and Tensile Properties of 7075 Al Compacted from Melt-Spun Ribbon", *J. Inst. Metals* **100** (1972) 142-5.

Reported microstructure and mechanical properties of hot-pressed and extruded melt-spun ribbon of 7075 Al. Heat-treatment gave a grain size of 1 to 10 μm, a yield strength 10% higher than for the conventionally-produced alloy, and superplasticity at ~400°C.

A31. E. PHILOFSKY, K. V. RAVI, J. BROOKS, and E. HALL, "Phase Transformations in Eutectic Au-Si Alloys on Single Crystal Si", *J. Electrochem. Soc.* **119** (1972) 527-30.

Reported metallographic, resistivity, XRD and electron diffraction studies of phase transformations in Au-18.6 at. % Si films solidified on Si single crystal wafers at various dT/dt. Metastable structures were obtained at $dT/dt > 10^3$ K sec^{-1}.

A32. D. E. POLK, "The Structure of Glassy Metallic Alloys", *Acta Metallurgica* **20** (1972) 485-91.

A structural model was shown to account well for the preferred composition range, radial distribution function and densities of AS metallic alloys and their excess entropies of mixing in the liquid state.

A33. D. E. POLK and D. TURNBULL, "Flow of Melt and Glass Forms of Metallic Alloys", *Acta Metallurgica* **20** (1972) 493-8.

Reported and discussed dependence on *T* of viscosity of AS Au-13.65 at. % Ge-9.45 at. % Si in relation to behaviour of the liquid form. Non-Newtonian flow was predicted above a critical strain-rate beyond which the AS structure becomes non-homogeneous.

A34. B. PREDEL and G. SCHLUCKEBIER, "On Metastable Phases in the Al-Ge System Obtained by extremely Rapid Solidification", *Z. Metallk.* **63** (1972) 198-203 (in German).

Reported lattice parameters and decomposition by continuous precipitation above 200°C of solid solutions extended up to 13 at. % Ge in Al by quenching the melt.

A35. P. RAMACHANDRARAO, M. LARIDJANI, and R. W. CAHN, "Diamond as a Splat-Cooling Substrate", *Z. Metallk.* **63** (1972) 43-9.

Reported TSSE of 17.3 at. % Cu in Al and formation of AS Al-30 at. % Ge (eutectic compositions at equilibrium) using a gun technique with a liquid nitrogen-cooled diamond quenching substrate.

A36. P. RAMACHANDRARAO, M. G. SCOTT, and G. A. CHADWICK, "Constitution and Microstructure of Rapidly Solidified Al-Ge Alloys", *Phil. Mag.* **25** (1972) 961-82.

Reported XRD, TEM, electron microanalysis and DTA studies of splat-cooled Al-15 to 50 at. % Ge. Local dT/dt estimated by the dendrite method [41, 47] indicated TSSE up to 50 at. % Ge at the highest dT/dt (~10^9 K sec^{-1}) and formation of two MCS phases at ~10^4 sec^{-1} to 10^8 K sec^{-1}. A further transitional MCS phase formed on thermal decomposition.

A37. R. RAY, B. C. GIESSEN, and N. J. GRANT, "The Constitution of Metastable Ti-Rich Ti-Fe Alloys: An Order-Disorder Transition", *Metall. Trans.* **3** (1972) 627-9.

In studies of splat-cooled Ti-10 to 50 at. % Fe alloys, reported formation of a partially disordered off-stoichiometric solid solution at 35 to 50 at. % Fe.

A38. A. REVCOLEVSCHI and N. J. GRANT, "Study of a Splat-Cooled Cu-Zr Noncrystalline Phase", *Metall. Trans.* **3** (1972) 1545-8.

Reported formation of AS Cu-40 at. % Zr by splat cooling and its thermal decomposition at 477°C with a heat release ~700 cal mol^{-1}. High resolution TEM showed no trace of crystallinity in the AS-phase but showed gradual crystallization on heating.

A39. H. RUPPERSBERG and H. J. BOLD, "Preparation of Ultrafine Powder by Spark Erosion in Liquid Inert Gases", *Metall.* **26** (1972) 34-8 (in German). See *Metals Abs.* **5** No. 7 (1972) 54-0328.

Reported formation of metastable phases in 100 Å powders of several pure elements and Cu-40 at. % and Cu-Ni formed and quenched from the melt by electro-discharge machining under liquid inert gases.

A40. V. K. SARIN and N. J. GRANT, "Cu-Zr and Cu-Zr-Cr Alloys Produced from Rapidly Quenched Powder", *Metall. Trans.* **3** (1972) 875-8.

Reported microstructures and mechanical properties of Cu-0.2 to 0.8 at. % Zr and Cu-0.1 at. % Zr-0.32 at. % Cr hot extruded from powder made and quenched from the melt by nitrogen atomization (dT/dt ~ 10^3 to 10^4 K sec^{-1}).

A41. T. E. SHARON and C. C. TSUEI, "Magnetism in Amorphous Fe-Pd-P Alloys", *Phys. Rev.* **B5** (1927) 1047-64.

Reported Fe^{57} Mössbauer study of magnetic properties of AS $(Fe_xPd_{80-x})P_{20}$ with $13 \leqslant x \leqslant 44$ made by quenching the melt. Results indicated weakly coupled Fe atoms in all the alloys residing in low effective fields and thereby giving rise to a Kondo effect.

A42. A. K. SINHA and P. DUWEZ, "Radial Distribution Function of Amorphous Mn-P-C Alloy", *J. Appl. Phys.* **43** (1972) 431-44.

Reported XRD determination of the radial distribution function of AS Mn-15 at. % P-10 at. % C made by quenching the melt. A structural model based on dense random packing of Mn atoms with metalloid atoms in interstices was considered.

A43. J. D. SPEIGHT, "Metastable Phases in Liquid-Quenched Alloys of Cr and Mn with Sb", *Metall. Trans.* **3** (1972) 1011-12.

Reported XRD studies of the constitution of splat-cooled Sb alloys with Cr, Mn, Fe, Co and Ni. New MCS phases were found for 6 to 12 at. % and 9.7 to 12 at. % Mn.

A44. P. K. SRIVASTAVA, B. C. GIESSEN, and N. J. GRANT, "A Noncrystalline Pt-Sb Phase and Its Equilibration Kinetics", *Metall. Trans.* **3** (1972) 977-82.

Reported formation by splat cooling of AS Pt-30 to 43 at. % Sb and Si-32 at. % Pt and XRD, electron diffraction and TEM studies of the decomposition kinetics of AS Pt-34% Sb (eutectic at equilibrium).

A45. C. SURYANARAYANA, "Metallography of Al-Ge Alloys Quenched from the Melt", *Trans. Indian Inst. Metals* **25** No. 1 (1972) 36-42.

The Al-rich metastable phase in Al-Ge alloys was identified by optical microscopy as forming six-faced pyramids, mostly regular but occasionally distorted. A smaller amount of superheat yielded truncated pyramids. Electron microprobe analysis aided in establishing the composition of the pyramids. See also [219].

A46. D. R. UHLMANN, "A Kinetic Treatment of Glass Formation", *J. Non-Cryst. Solids* **7** (1972) 337-48.

Presented kinetic treatment of glass formation based on the construction of time-T-transformation curves. Comparison with experimental data dependent mainly on a knowledge of viscosity versus T relationships and included AS Au-Ge-Si made by splat-cooling.

A47. N. I. VARICH and A. N. PETRUNINA, "Metastable Phases in Binary Alloys Crystallized at High Cooling Rate", *Fiz. Metal. Metalloved.* **33** (1972) 335-8 (in Russian). See *Metals Abs.* **5** No. 8 (1972) 12-1047. English version to appear in *Phys. Metals Metallog.* **33** No. 2 (1972).

Reported metallographic and XRD study of Ni up to 40% (Ta, Mo, Nb, Ti or Zr) solidified at $dT/dt \sim 10^8$ K sec^{-1}. Quenching from the melt at 2000°C gave maximum TSSE, while from 1900°C gave MCS as well.

A48. R. WANG, "Formation of Metastable Low Temperature, Allotropic Solid Solutions in Rare Earth-Zr Systems", *Metall. Trans.* **3** (1972) 1213-21.

Reported use of splat-cooling to obtain TSSE of Gd, Tb, Dy, Ho, Er and Lu in Zr, complete for Dy, Ho, Er and Lu in Zr. A martensitic transformation was reported at $dT/dt > 10^7$ K sec^{-1}. See also [176].

A49. H. WARLIMONT, "Extremely Rapid Solidification", *Z. Metallk.* **63** (1972) 113-18 (in German).

A review of information on techniques of solidification at high dT/dt, and of the resultant microstructures, properties and possible commercial applications.

Addendum for 1972

A50. T. ARAI and N. KOMATSU, "Heat Treatment Characteristics of Tool Steels Quenched from the Liquid State", *Tetsu-to-Hagané* **58** (1972) 1246-63 (in Japanese). See *Metals Abs.* **6** No. 1 (1973) 56-0041.

Compared hardness values after heat treatment of tool steels quenched from the melt with those of the same forged steels. Hardness differences were attributed to expected differences in carbide particle sizes. See also [A2].

A51. E. BABIĆ, P. J. FORD, C. RIZZUTO, and E. SALAMONI, "Superconductivity and Localized Spin Fluctuations in Concentrated Al-3d-Transition Metal Alloys", *J. Low Temp. Phys.* **8** (1972) 219-28.

Reported and discussed measurements of superconducting transition T as a function of concentration for extended solid solutions of Ti, V, Cr, Fe and Co in Al prepared by quenching the melt.

A52. E. BABIĆ, R. KRSNIK, B. LEONTIĆ, M. OČKO, Z. VUČIĆ, I. ZORIĆ, and E. GIRT, "Temperature Dependent Impurity Resistivity in Al-based 3-d Transition Metal Alloys", *Solid State Commun.* **10** (1972) 691-5.

Reported and discussed measurements at 4.2 and 500 K of impurity resistivity as a function of concentration for extended solid solutions of Ti, V, Cr, Fe, Co and Ni in Al prepared by quenching the melt.

A53. H. S. CHEN and H. HAEMMERLE, "Excess Specific Heat of a Glassy $Pd_{0.775}Cu_{0.06}Si_{0.165}$ Alloy at Low Temperature", *J. Non-Cryst. Solids* **11** (1972) 161-9.

Reported and discussed measurements of specific heat of Pd-6 at. % Cu-16.5 at. % Si alloy as a function of T between 2 and 18 K for both its glassy form as-quenched from the melt and a crystalline form produced by subsequent annealing.

A54. S. JUSTI, K. KÖRBER, and K. LÖHBERG, "A Contribution to the Problem of Refinement of Al-Si Alloys", *Giessereiforschung* **24** (1972) 37-44 (in

German). English version to appear in *Giesserei-forschung* in English.

Included effect on microstructure of cooling Al-Si eutectic alloy from the melt at $dT/dt \sim 10^5$ to 10^6 K sec^{-1}.

A55. H. KAHKÖNEN, "Small-angle X-ray Diffraction Study of Pre-precipitation in Al-Ag Alloys Quenched from the Liquid State", *Physica Fennica* (*Collected Reprints*) **A7** No. 4 (1972) Paper No. 399.

Reported increase in mean size of GP zones in ageing Al-15 and 20 wt% Ag rapidly quenched from the liquid state. See also [A23].

A56. E. LAINE, "Effect of Liquisol Quenching upon Lattice Parameters and Vacancy Concentration of Cd", *Phys. Stat. Sol.* **a13** (1972) K27-30.

Reported smaller lattice parameters for Cd rapidly quenched from the melt (QT:6i, $dT/dt > 10^5$ K sec^{-1}, $z \sim 25$ μm), than for slowly cooled powder, values tending to those of the powder on annealing. The results were interpreted as indicating a vacancy concentration $\sim 4 \times 10^{-3}$ at the melting point. See also [67].

A57. A. C. MOTA, P. BREWSTER, and R. WANG, "Superconductivity in the Mg-Cd System: Extrapolated T_c for Pure Magnesium", *Phys. Letters* **41A** (1972) 99-101.

Reported measurements of superconducting transition T as a function of concentration for continuous metastable solid solutions of Mg-Cd alloys made by quenching the melt, extrapolating the results to obtain a value of 4.5×10^{-3} K for pure Mg.

A58. A. F. POLESYA and L. S. SLIPCHENKO, "Phase Composition of Ni-Sn Alloys Quenched from the Liquid State", *Izvest. VUZ, Tsvetnaya Met.* **1972** No. 3 pp. 128-33 (in Russian). See *Metals Abs.* **6** No. 1 (1973) 11-0054.

Reported formation of orthorhombic MCS phase on quenching from the melt Ni-Sn alloys close to the eutectic composition.

A59. B. PREDEL and G. SCHLUCKEBIER, "Investigation of the Structure, Thermodynamics and Kinetics of Decomposition of Metastable Ag-Cu Solid Solutions Produced by Splat Cooling", *Z. Metallk.* **63** (1972) 782-9 (in German).

Reported and discussed lattice parameter measurements for continuous Ag-Cu solid solutions made by quenching the melt and calorimetric studies of their decomposition on annealing.

A60. R. RAY, S. H. HAHN, and B. C. GIESSEN, "Superconductivity of Nonsubstitutional Solid Solutions Pb(Ag) and Pb(Au)", *Acta Metallurgica* **20** (1972) 1335-7.

Reported measurements of superconducting transition T as a function of concentration in extended Pb-up to 12 at.% Ag or Au made by quenching the melt. The results were consistent with a di-substitutional model in which two solute atoms substitute for one solvent atom. See also [A61].

A61. R. RAY, M. SEGNINI, and B. C. GIESSEN, "Concentrated Disubstitutional Metallic Solid Solutions", *Solid State Commun.* **10** (1972) 163-7.

Reported XRD and density measurements for extended solid solutions of up to 15 at.% Cu and Fe in Gd made by quenching the melt. Results were consistent with a disubstitutional model. See also [A60].

A61a. A. V. REVYAKIN, B. D. GLYUZITSKY, and A. M. SAMARIN, "Equipment for the Solidification of Refractory Metals at High Cooling Rates", *Zavod. Lab.* **38** (1972) 368-9 (in Russian). See *Metals Abs.* **6** No. 2 (1973) 22-0156. Translation to appear in *Ind. Lab.* (1972).

Described apparatus for rapid cooling of refractory and reactive metals from the melt, by melting drops from a rod on to a rotating Cu disc ($z = 100$ to 200 μm). Gave formula for dT/dt and illustrated grain refinement at high dT/dt for Nb-2% Al_2O_3.

A62. H. P. SINGH, R. WANG, and L. E. MURR, "Direct Observation of Dislocations in Splat-cooled Co_5Pr", *J. Mater. Sci.* **7** (1972) 1346-8.

Reported identification of dislocations in splat-cooled Co-20 at.% Pr by formation of TEM Moiré patterns in layered samples.

A63. T. TAKAMORI and R. ROY, "Preparation of Thin Glass Films for Transmission Electron Microscopy by Splat Cooling", *J. Amer. Ceram. Soc.* **55** (1972) 538-9.

Reported formation by splat cooling of specimens suitable for TEM in SiO_2-rich concentrations of SiO_2-Al_2O_3 glasses.

A64. T. TAKAMORI and R. ROY, "Splat-Cooling in Controlled Atmospheres", *J. Non-Cryst. Solids* **11** (1972) 251-4.

Describes modification of QT:1f [250] to allow operation in controlled atmospheres, obtaining a glass-forming composition range for Ge-Te similar to Duwez [8]. See also *J. Mater. Sci.* **8** (1973) 415.

A65. A. TONEJC, "Phase Transformations in Al-rich Al-W Alloys Rapidly Quenched from the Melt", *J. Mater. Sci.* **7** (1972) 1292-8.

Reported XRD study of as-quenched constitution and annealing behaviour (50 to 650°C) of Al-4.3 to 11.7 wt% W quenched from the melt by a two-piston method. Presence of MCS phases increased the resistance to decomposition of the extended αAl solid solution.

A65a. R. WANG, K. S. KIM, and Y. B. KIM, "Preparation of Fine Powders of Rare Earth-Co by Rapid Quenching Technique", in Digests of Intermag Conference, Kyoto, April 1972, Inst. of Electrical and Electronic Engrs., New York, 1972, Paper 37.1. Reported increased coercive forces for Co_5 (Pr, MM, Y or Sm) powders made by splat cooling (QT:1a, $dT/dt \sim 10^7$ K sec^{-1}) and bonded with epoxy resin.

A66. N. I. VARICH and A. N. PETRUNINA, "Crystallization of Ni-Cr and Ni-V Alloys at Very High Cooling Rates", *Izvest VUZ, Tsvetnaya Met.* **1972** No. 2 pp. 92-5 (in Russian). See *Metals Abs.* **5** No. 12 (1972) 12-1482.

Reported XRD and microhardness studies of TSSE up to 54 at. % Cr and 53 at. % V in Ni by quenching the melt $dT/dt \sim 10^8$ K sec^{-1}). In Ni-Cr, and MCS phase Cr_3Ni formed at high superheat.

A67. J. VITEK and N. J. GRANT, "Cooling Rates in Splat Cooling", *J. Mater. Sci.* **7** (1972) 1343-4.

In commenting on [2, A1, A21, A22], pointed out the effect of atmospheric conditions on dT/dt and the possibility of using extent of solute supersaturation as another indicator of dT/dt.

Received and accepted 1 December 1972.