UDC 669.35'6'779

WROUGHT MATERIALS

COPPER-TIN ALLOYS
Tin Bronzes
Phosphor Bronzes

Cu Sn8

Common names: 9% Phosphor Bronze
Phosphor Bronze, 8% C

A copper-tin alloy with an alpha phase structure, possibly also containing a small amount of delta phase depending upon fabrication history. The high tin content and the phosphorus addition impart to the alloy excellent wear resistance, fatigue strength and bearing properties. Cu Sn8 also has high strength and hardness, as well as good resistance to corrosion. The most commonly used wrought forms are strip, rod, wire and tube.

COMPOSITION (weight %)

Sn	7.5 -9.0
P	0.02–0.40
Cu	rem.

1 SOME TYPICAL USES

Chemical
Wire for Fourdrinier cloth; components for the chemical, textile and papermaking industries.

Electrical
Heavy-duty springs, clips and switch components.

Mechanical
Heavy-duty springs; diaphragms; wire brushes; Bourdon tubing; pinions, gears and sleeve bushings; pump components; clutch friction plates; bridge bearing plates.

2 PHYSICAL PROPERTIES

	Metric Units	English Units
2.1 Density at 20 °C *68 °F*	8.80 g/cm³	0.320 lb/in³
2.2 Melting range [a]	860–1 040 °C	1 580–1 905 °F
2.3 Coefficient of thermal expansion (linear) at:		
20 to 100 °C *68 to 212 °F*	0.000 017 per °C	0.000 009 per °F
20 to 300 °C *68 to 572 °F*	0.000 018 „ „	0.000 010 „ „
2.4 Specific heat (thermal capacity) at:		
20 °C *68 °F*	0.09 cal/g °C	0.09 Btu/lb °F
2.5 Thermal conductivity at:		
20 °C *68 °F*	0.11–0.15 cal cm/cm² s °C	27–36 Btu ft/ft² h °F
2.6 Electrical conductivity (volume) at:		
20 °C *68 °F* (annealed)	5.8–8.1 m/ohm mm²	10–14% IACS
2.7 Electrical resisitivity (volume) at:		
20 °C *68 °F* (annealed)	0.17–0.12 ohm mm²/m 17 –12 microhm cm	100–74 ohms (circ mil/ft) 6.8–4.8 microhm in
2.8 Temperature coefficient of electrical resistance at:		
20 °C *68 °F* (annealed)	0.000 6 per °C (10% IACS) 0.000 7 „ „ (14% IACS)	0.000 3 per °F (10% IACS) 0.000 4 „ „ (14% IACS)
applicable over range from 0 to 100 °C *32 to 212 °F*		
2.9 Modulus of elasticity (tension) at 20 °C *68 °F*:		
annealed	11 400 kg/mm²	16 200 000 lb/in²
cold worked [b]	9 000–10 800 kg/mm²	12 800 000–15 400 000 lb/in²
2.10 Modulus of rigidity (torsion) at 20 °C *68 °F*:		
annealed	4 200 kg/mm²	6 000 000 lb/in²
cold worked [b]	3 300–4 000 kg/mm²	4 700 000–5 700 000 lb/in²

(a) For high phosphorus contents, the temperatures, especially at the bottom of the range, will be lower.
(b) The modulus values progressively decrease, within the ranges shown, as the amount of cold work increases.

N.B.: The values shown in Section 2, which have been appropriately rounded in view of the composition range involved, are based on selected literature references.

INDEX NUMBERS RELATE TO LITERATURE REFERENCES (see page 8); INDEX LETTERS RELATE TO FOOTNOTES AT END OF TABLE.

Prepared by
CONSEIL INTERNATIONAL POUR LE DEVELOPPEMENT DU CUIVRE (CIDEC)
100, rue du Rhône - 1204 GENEVE

Distributed by
C.I.C.L.A.
Centre d'Information Cuivre, Laitons, Alliages
67, Boulevard Berthier, 75 Paris XVIIe

DATA SHEET No. G 5
© Cu Sn8
1971 Edition

3 FABRICATION PROPERTIES

The information given in this table is for general guidance only, since many factors influence fabrication techniques.
The values shown are approximate only, since those used in practice are dependent upon form and size of metal, equipment available, techniques adopted and properties required in the material.

	Metric Units	English Units
3.1 Casting temperature range	1 090–1 150 °C	1 995–2 100 °F
3.2 Annealing temperature range	500– 725 °C	930–1 335 °F
Stress relieving temperature range	200– 350 °C	390– 660 °F
3.3 Hot working temperature range	—	—
3.4 Hot formability	Very limited (Not recommended)	
3.5 Cold formability	Good	
3.6 Cold reduction between anneals	60% max.	
3.7 Machinability:	See General Data Sheet No. 2	
Machinability rating (free-cutting brass = 100)	20	
3.8 Joining methods:	See General Data Sheet No. 3.7	
Soldering	Excellent	
Brazing	Excellent	
Oxy-acetylene welding	Fair	
Carbon-arc welding	Fair	
Gas-shielded arc welding	Good	
Coated metal-arc welding	Fair	
Resistance welding: spot and seam	Good	
butt	Excellent	

4 NATIONAL SPECIFICATIONS FOR MANUFACTURED FORMS

and ISO Recommendation

Country	Designation of Standards	Designation of Material in Standards	Specification for Chemical Composition[a]	Plate Sheet Strip	Rod	Wire	Tube	Sections / Shapes	Forgings
Australia . . .	SAA	—	—	—	—	—	—	—	—
Belgium . . .	NBN	Br Sn8 P	—	266.21	266.21	266.21	—	—	—
Canada . . .	CSA	HC. TJ80 521	—	HC.4.5	HC.5.5.	HC.5.23	—	HC.5.5	—
Chile	INDITECNOR	Cu Sn8 P	NCh248.of.68	—	—	—	—	—	—
France. . . .	NF	—	—	—	—	—	—	—	—
Germany . . .	DIN	Cu Sn8 (2.1030)	17 662	1780 17 670	17 672	17 672 17 682	17 671	—	—
India	IS	—	—	—	—	—	—	—	—
Italy	UNI	B 8	—	2527	2527	2527	2527	2527	—
Japan	JIS	PBP3 PBSP PBSR PBR3 PBSPS PBSRS PBB3 PBW3	—	H 3731 H 3732	H3741	H3751	—	—	—
Netherlands .	N or NEN[b]	Cu-Sn9	NEN 6030	NEN 6033	—	—	—	—	—
South Africa .	SABS	—	—	—	—	—	—	—	—
Spain	UNE	Cu Sn8	—	37 103	—	37 103	—	—	—
Sweden . . .	SIS	54 31	—	14 54 31	14 54 31	—	—	—	—
Switzerland . .	VSM	Cu Sn8	—	10 801	10 801	10 801	10 801	—	—
United Kingdom . .	BS	PB104	—	—	2874[d]	—	2871[e]	—	—
United States[c]	ASTM	No. 521	—	B 103 B 139	B 139	B 159	—	B 139	—
International Organization for Standardization	ISO	Cu Sn8	R 427	—	—	—	—	—	—

(a) Applicable when the chemical composition is not given in the specifications for wrought forms.
(b) Older specifications bear prefix N; for new specifications the NEN prefix is used.
(c) In the United States, bar and flat wire are covered under the Plate-Sheet-Strip column.
(d) Included in imperial units edition (1962) but deleted from metricated revision (1969).
(e) Included in imperial units edition (1957) but deleted from metricated revision (1971).

5.1 MECHANICAL PROPERTIES AT ROOM TEMPERATURE [a]

5.1.1 Typical Tensile Properties and Hardness Values—Metric Units

This table is representative of practice in many European countries. For British and American practices, see tables 5.1.2 and 5.1.3, respectively.

The values shown represent reasonable approximations for general engineering use, taking account of variations in composition and manufacturing procedures. For design purposes, national specifications should be consulted.
For a given temper, individual elongation values may show some variation above or below the typical values indicated.

Form	Temper	Tensile Strength kg/mm²	Proof Stress 0.2% offset kg/mm²	Elongation		Hardness		Shear Strength kg/mm²	Typical Size Related to Properties Shown [b]
				%	gauge length	Brinell	Vickers		
Sheet Strip	Annealed (grain size 0.025 mm)	42	17	65	50 mm	85	89	31	0.2–3 mm thick
	Typical Cold Worked Tempers	50	40	32	$5.65\sqrt{S_o}$	150	155	35	over 1 mm thick
		60	53	14	50 mm	180	190	39	0.5–3 mm thick
		70	65	6	50 mm	200	210	41	0.2–1.5 mm thick
		80	77	2	50 mm	225	235	42	up to 0.5 mm thick
		85	82	—	—	240	250	43	up to 0.2 mm thick
Rod [c]	Annealed	42	17	65	$5.65\sqrt{S_o}$	85	89	31	—
	Typical Cold Worked Tempers	50	40	35	$5.65\sqrt{S_o}$	150	155	35	5–40 mm diam. or equivalent area
		60	53	18	$5.65\sqrt{S_o}$	180	190	39	5–12 mm diam. or equivalent area
		70	65	8	$5.65\sqrt{S_o}$	200	210	41	3– 6 mm diam. or equivalent area
Wire	Annealed	43	—	55	100 mm	—	—	30	0.5–3 mm diam.
	Typical Cold Drawn Tempers	75	—	4	100 mm	—	—	42	0.5–3 mm diam.
		85	—	2	100 mm	—	—	43	0.5–2 mm diam.
		95	—	—	—	—	—	44	up to 1 mm diam.
		105	—	—	—	—	—	45	up to 0.5 mm diam.
Tube	Annealed	42	17	65	$5.65\sqrt{S_o}$	85	89	31	—
	Typical Cold Worked Tempers	48	35	30	$5.65\sqrt{S_o}$	140	145	34	10–35 mm O.D. 2–5 mm wall
		56	50	20	$5.65\sqrt{S_o}$	175	185	37	10–35 mm O.D. 1–5 mm wall

(a) It will be noted that tables 5.1.1, 5.1.2 and 5.1.3, giving typical tensile properties and hardness values in Metric, SI and English, and American units, respectively, are not directly comparable. This is because the properties quoted reflect to some extent the metalworking techniques, specification practices and testing procedures in the countries concerned, and in view of the different sizes of products referred to in these tables. Individual manufacturers of semi-fabricated products can, however, normally meet the requirements of any national standard.

(b) It is possible to obtain sizes outside the ranges given in this column, but information on their mechanical properties should be obtained from the metal manufacturers.

(c) The mechanical properties will be largely dependent upon the size and cross-sectional area or complexity of the product.

5.1.2 Typical Tensile Properties and Hardness Values—SI and English Units

This table is based on British practice. For other European and American practices, see tables 5.1.1 and 5.1.3, respectively.

The values shown represent reasonable approximations for general engineering use, taking account of variations in composition and manufacturing procedures. For design purposes, national specifications should be consulted.
For a given temper, individual elongation values may show some variation above or below the typical values indicated.

Form	Temper [a]	Tensile Strength		Proof Stress 0.1% offset		Elongation		Vickers Hardness	Shear Strength		Typical Size Related to Properties Shown [b]
		hbar	ton/in²	hbar	ton/in²	%	gauge length		hbar	ton/in²	
Strip	Annealed (grain size~0.03 mm)	42	27	15	10	65	50 mm (2 in.)	90	32	20	0.2–3 mm (0.008–0.125 in.) thick
	Cold Worked Extra Spring Hard	83	54	71	46	4	50 mm (2 in.)	245	46	30	0.2–0.5 mm (0.008–0.02 in.) thick
Rod [c]	Annealed	42	27	15	10	60	$5.65\sqrt{S_o}$	90	32	20	—
	Cold Worked	48	31	32	21	30	$5.65\sqrt{S_o}$	150	34	22	40–70 mm (1.6–2.8 in.) diam. or equivalent area
	As Manufactured	51	33	36	23	28	$5.65\sqrt{S_o}$	170	36	23	20–40 mm (0.8–1.6 in.) diam. or equivalent area
		54	35	39	25	23	$5.65\sqrt{S_o}$	180	37	24	6–20 mm (0.25–0.8 in.) diam. or equivalent area
Wire	Annealed	43	28	—	—	60	100 mm (4 in.)	—	32	21	0.5–2.5 mm (0.02–0.10 in.) diam.

(a) The recognised temper designations used in the relevant or nearest British Standards are also given to clarify the cold-worked tempers shown.
(b) It is possible to obtain sizes outside the ranges given in this column, but information on their mechanical properties should be obtained from the metal manufacturers.
(c) The mechanical properties will be largely dependent upon the size and cross-sectional area or complexity of the product.

5.1.3 Typical Tensile Properties and Hardness Values—American Units

This table is based on American practice and the temper designations shown are those referred to in ASTM and other American standards. For British and other European countries' practices, see tables 5.1.2 and 5.1.1 respectively.

The values shown represent reasonable approximations for general engineering use, taking account of variations in composition and manufacturing procedures. For design purposes, national specifications should be consulted.
For a given temper, individual elongation values may show some variation above or below the typical values indicated.

Form	Temper	Tensile Strength psi	Yield Strength 0.5% extension under load psi	Elongation		Rockwell Hardness			Shear Strength psi	Typical Size Related to Properties Shown [a]
				%	gauge length	F	B	30 T		
Flat Products (Plate Sheet Strip and Bar)	Annealed (grain size 0.025 mm)	60 000	25 000	64	2 in.	82	—	—	44 000	0.040 in. thick
	Cold Worked									
	Half Hard	78 000	59 000	31	2 in.	—	88	73	53 000	0.040 in. thick
	Hard	93 000	75 000	12	2 in.	—	95	78	57 000	"
	Spring	111 000	89 000	4	2 in.	—	98	81	61 000	"
	Extra Spring	120 000	—	2	2 in.	—	100	82	61 000	"
Rod [b]	Annealed	60 000	—	—	—	—	—	—	44 000	0.20 in. diam.
	Cold Worked									
	Hard	124 000	—	—	—	—	—	—	63 000	0.20 in. diam.
	Half Hard (20%)	81 000	65 000	33	2 in.	—	85	—	54 000	1.0 in. diam.
Wire	Annealed	60 000	—	—	—	—	—	—	44 000	0.080 in. diam.
	Cold Worked									
	Quarter Hard	84 000	—	—	—	—	—	—	54 000	0.080 in. diam.
	Half Hard	106 000	—	—	—	—	—	—	60 000	"
	Hard	133 000	—	—	—	—	—	—	64 000	"
	Extra Hard	140 000	—	—	—	—	—	—	64 000	"

(a) It is possible to obtain sizes different from those given in this column, but information on their mechanical properties should be obtained from the metal manufacturers.
(b) The mechanical properties will be largely dependent upon the size and cross-sectional area or complexity of the product.

5.2 MECHANICAL PROPERTIES AT LOW TEMPERATURE

5.2.1 Tensile Properties

Form	Temper	Testing Temperature		Tensile Strength			Proof Stress 0.2% offset kg/mm²	Elongation	
		°C	°F	kg/mm²	ton/in²	psi		%	gauge length
Rod (1) **5 mm diam. 0.2 in. diam.**	Cold Worked and Stress Relieved	27	81	**68**	43	96 500	—	**75**	$11.3\sqrt{S_o}$
		— 73	— 99	**82**	52	116 500	—	**83**	$11.3\sqrt{S_o}$
		—173	—279	**104**	66	148 000	—	**81**	$11.3\sqrt{S_o}$
		—198	—324	**110**	70	156 500	—	**82**	$11.3\sqrt{S_o}$
Rod (2) **19 mm diam. 0.75 in. diam.**	Cold Worked (a)	24	75	83	52.5	**118 000**	**78.7** (b)	**20**	1 in.
		—196	—320	107	68	**152 000**	**98.4** (b)	**30**	1 in.
		—253	—423	118	75	**168 000**	**108** (b)	**25**	1 in.

(a) Quoted as "hard drawn (Rockwell hardness B 100)" in original document, but amount of cold work not defined.

(b) This value was originally reported in psi; in this table it is given in kg/mm² to 3 significant figures.

N.B.: — Original values are printed in **bold type**; other values are converted.

— Data not available: Proof stress, 0.1% offset,
Yield strength, 0.5% extension under load,
Impact strength,
Reduction of area.

5.3 MECHANICAL PROPERTIES AT ELEVATED TEMPERATURE

5.3.1 Short-Time Tensile Properties

Form	Temper	Testing Temperature		Tensile Strength			Proof Stress 0.2% offset kg/mm²	Elongation	
		°C	°F	kg/mm²	ton/in²	psi		%	gauge length
Rod [1] 5 mm diam. 0.2 in. diam.	Cold Worked and Stress Relieved	27	81	**69**	44	98 000	—	**75**	$11.3\sqrt{S_o}$
		77	171	**65**	41.5	92 500	—	**63**	$11.3\sqrt{S_o}$
		127	261	**75**	47.5	106 500	—	**80**	$11.3\sqrt{S_o}$
		177	351	**70**	44.5	99 500	—	**73**	$11.3\sqrt{S_o}$
		227	441	**49**	31	69 500	—	**45**	$11.3\sqrt{S_o}$
		277	531	**30**	19	42 500	—	**15**	$11.3\sqrt{S_o}$
		327	621	**23**	14.5	32 500	—	**12**	$11.3\sqrt{S_o}$
		377	711	**20**	12.5	28 500	—	**13**	$11.3\sqrt{S_o}$
		427	801	**17**	11	24 000	—	**14**	$11.3\sqrt{S_o}$
		477	891	**11**	7	15 500	—	**15**	$11.3\sqrt{S_o}$
		527	981	**11** [a]	7	15 500	—	**15**[a]	$11.3\sqrt{S_o}$
Rod [3] 10 mm diam. 0.4 in. diam.	Cold Worked ~10–15%	20	68	**58**	37	82 500	**50**	**30**	$11.3\sqrt{S_o}$
		100	212	**57**	36	81 000	**47**	**34**	$11.3\sqrt{S_o}$
		200	392	**54**	34.5	77 000	**44**	**28**	$11.3\sqrt{S_o}$
		300	572	**43**	27.5	61 000	**35**	**26**	$11.3\sqrt{S_o}$
		400	752	**28**	18	40 000	**22**	**14**	$11.3\sqrt{S_o}$
Tube [5] 4–5 mm wall 0.16–0.2 in. wall	Cold Worked [b]	20	68	**57**	36	81 000	**45**	**47**	$5.65\sqrt{S_o}$
		100	212	**57**	36	81 000	**47**	**48**	$5.65\sqrt{S_o}$
		200	392	**55**	35	78 000	**46**	**37**	$5.65\sqrt{S_o}$
		300	572	**49**	31	69 500	**40**	**17**	$5.65\sqrt{S_o}$
		400	752	**35**	22	50 000	**31**	**6**	$5.65\sqrt{S_o}$
Tube [4]	Cold Worked	21	70	55	35	**78 000**	—	**30**	2 in.
		99	210	55	35	**78 000**	—	**32**	2 in.
		199	390	54	34.5	**77 000**	—	**28**	2 in.
		299	570	52	33	**74 000**	—	**27**	2 in.
		399	750	33	21	**47 000**	—	**15**	2 in.
		499	930	28	18	**40 000**	—	**11**	2 in.

[a] Extrapolated value.

[b] Quoted as "Hard and stress relieved" in original document, but amount of cold work not defined.

N.B.: — Original values are printed in **bold type**; other values are converted.

— Data not available: Proof stress, 0.1% offset,
Yield strength, 0.5% extension under load.

— Further data can be obtained from the following papers:

- Leech, E. A., Gregory, P. and Eborall, R. A Hot Impact Tensile Test and Its Relation to Hot-Working Properties, J. Inst. Metals, Vol. 83 (1954–55), pp. 347–353.
- Köster, W. and Speidel, M. O. Der Einfluss der Temperatur und der Korngrösse auf die ausgeprägte Streckgrenze von Kuperferlegierungen. Z. Metallkunde, vol. 56 (1965), pp. 585–598.

5.3.2 Creep Properties

At the date of publication of this sheet, no data relating to this material have been traced.

5.4 FATIGUE PROPERTIES

5.4.1 Fatigue Strength at Room Temperature

Form	Temper	Number of Cycles × 10^6	Metric Units kg/mm² Tensile Strength	Metric Units kg/mm² Fatigue Strength	English Units ton/in² Tensile Strength	English Units ton/in² Fatigue Strength	American Units psi Tensile Strength	American Units psi Fatigue Strength
Sheet [6] 0.5 mm 0.02 in.	Annealed	100	36.5	12 [a]	23	7.5 [a]	**51 800**	**17 250** [a]
	Cold Worked 37%	100	62	15.5 [a]	39.5	10 [a]	**88 000**	**22 000** [a]
	Cold Worked 60.5%	100	79.5	19 [a]	50.5	12 [a]	**112 900**	**27 000** [a]
	Cold Worked 69%	100	87.5	17 [a]	55.5	11 [a]	**124 800**	**24 500** [a]
Strip [7] 1 mm 0.04 in.	Annealed (grain size 0.035 mm)	100	39.5	17.5 [a]	25	11 [a]	**56 000**	**25 000** [a]
	Annealed (grain size 0.015 mm)	100	43	22 [a]	27	14 [a]	**61 000**	**31 000** [a]
	Cold Worked 21% [b]	100	50	22 [a]	31.5	14 [a]	**71 000**	**31 000** [a]
	Cold Worked 21% [c]	100	57	22.5 [a]	36	14.5 [a]	**81 000**	**32 000** [a]
	Cold Worked 37% [b]	100	64	22.5 [a]	40.5	14.5 [a]	**91 000**	**32 000** [a]
	Cold Worked 37% [c]	100	68	22 [a]	43.5	14 [a]	**97 000**	**31 000** [a]
	Cold Worked 50% [b]	100	71.5	21 [a]	45.5	13.5 [a]	**102 000**	**30 000** [a]
	Cold Worked 50% [c]	100	74	22 [a]	47	14 [a]	**105 000**	**31 000** [a]
	Cold Worked 60.5% [b]	100	78	23 [a]	49.5	14.5 [a]	**111 000**	**33 000** [a]
	Cold Worked 60.5% [c]	100	78	22 [a]	49.5	14 [a]	**111 000**	**31 000** [a]
	Cold Worked 69% [b]	100	81	22 [a]	51.5	14 [a]	**115 000**	**31 000** [a]
	Cold Worked 69% [c]	100	83.5	22 [a]	53	14 [a]	**119 000**	**31 000** [a]
Flat Products [8] 1 mm 0.04 in.	Cold Worked [d]	100	65.5	15.5 [a]	41.5	10 [a]	**93 000**	**22 000** [a]
Rod [9] 13 mm diam. 0.5 in. diam.	Annealed (grain size 0.020 mm)	1 000	41.5	22.5 [e]	26.5	14.5 [e]	**59 200**	**32 000** [e]
	Annealed (grain size 0.070 mm)	1 000	39	16 [e]	25	10.5 [e]	**55 500**	**23 000** [e]
	Cold Worked 15.2%	1 000	46.5	20.5 [e]	29.5	13 [e]	**66 000**	**29 000** [e]
	Cold Worked 30.1%	1 000	57	24 [e]	36	15 [e]	**81 000**	**34 000** [e]
	Cold Worked 50.1%	1 000	77.5	20.5 [e]	49	13 [e]	**110 300**	**29 000** [e]
Rod [10] 25.4 mm diam. 1 in. diam.	Annealed	100 [h]	39	15 [e]	24.5	9.5 [e]	**55 400**	**21 000** [e]
	Cold Worked and Stress Relieved [f]	100 [h]	57	15.5 [e]	36	10 [e]	**81 000**	**22 000** [e]
	Cold Worked and Stress Relieved [g]	100 [h]	66.5	12 [e]	42	7.5 [e]	**94 600**	**17 000** [e]

(a) Reversed-bending test.
(b) Ready-to-finish grain size 0.035 mm.
(c) Ready-to-finish grain size 0.015 mm.
(d) Quoted as "hard" in original document, but amount of cold work not defined.
(e) Rotating-beam test.
(f) Stress relieved 4 h at 191°C *(375°F)* in and cooled in oil bath.
(g) Stress relieved 4 h at 177°C *(350°F)* in and cooled in oil bath.
(h) Extrapolated value.

N.B.: — Original values are printed in **bold type**; other values are converted.
— Further data can be obtained from the following papers:-

- McKeown, J. A Rapid Method of Estimating the Fatigue Limit or Endurance Limit of Metals in Reverse Bending. Metallurgia (Manchr), Vol. 54 (1956) pp. 151–156, 158.
- Gohn, G. R. and Ellis, W. C. The Fatigue Characteristics of Copper-Nickel-Zinc and Phosphor Bronze Strip in Bending Under Conditions of Unsymmetrical Loading. Proc. ASTM, Vol. 47 (1947), pp. 713–724.

REFERENCES

MECHANICAL PROPERTIES (SECTION 5)

(1) Vöhringer, O. Das Verfestigungsverhalten von vielkristallinen α-Kupfer-Zinn-Legierungen. Thesis, Stuttgart University (1966).
(2) McClintock, R. M., Van Gundy, D. A. and Kropschot, R. H. Low-Temperature Tensile Properties of Copper and Four Bronzes. ASTM Bull. No. 240 (1959), Sept., pp. 47–50.
(3) Private communication from Carobronze AG, Germany.
(4) Wilkins, R. A., and Bunn, E. S. Copper and Copper-Base Alloys. McGraw-Hill Book Company, New York (1943).
(5) Private communication from Vereinigte Deutsche Metallwerke AG, Germany.
(6) Greenall, C. H., and Gohn, G. R. Fatigue Properties of Non-ferrous Sheet Metals. Proc. ASTM, Vol. 37 (1937), pp. 160–194.
(7) Metals Handbook, Vol. 1, 8th ed. American Society for Metals, Cleveland, Ohio (1961), p. 1028.
(8) Standards Handbook: Wrought Copper and Copper Alloy Mill Products – Part 2, Alloy Data CDA. Inc., New York. Pub. No. 102/8, 6th ed. (1968), p. 76
(9) Anderson, A. R., Swan, E. F. and Palmer, E. W. Fatigue Tests on Some Additional Copper Alloys, Proc. ASTM, Vol. 46 (1946), pp. 678–692.
(10) McAdam, D. J., Jr., Fatigue and Corrosion-Fatigue of Spring Material. Trans. ASME, Applied Mechanics, Vol. 51 (1929), pp. 45–58.