



**Copper Development
Association Inc.**
Copper Alliance

Introduction to Copper and Copper Alloys

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CDA Mission

The Copper Development Association, Inc. is a not-for-profit trade association that provides technical, market development, education and support services for the U.S. copper industry with a vision towards positively influencing the use of copper and its alloys in today's society.

Celebrating 50 years of service to the copper industry



1962 — 2012

Introduction to Copper and Copper Alloys

- § History
- § Copper Properties
- § Production
- § Properties
- § Alloy Families
- § Typical Uses of Select Alloys
- § Summary



History – Oldest Metal Known to Man

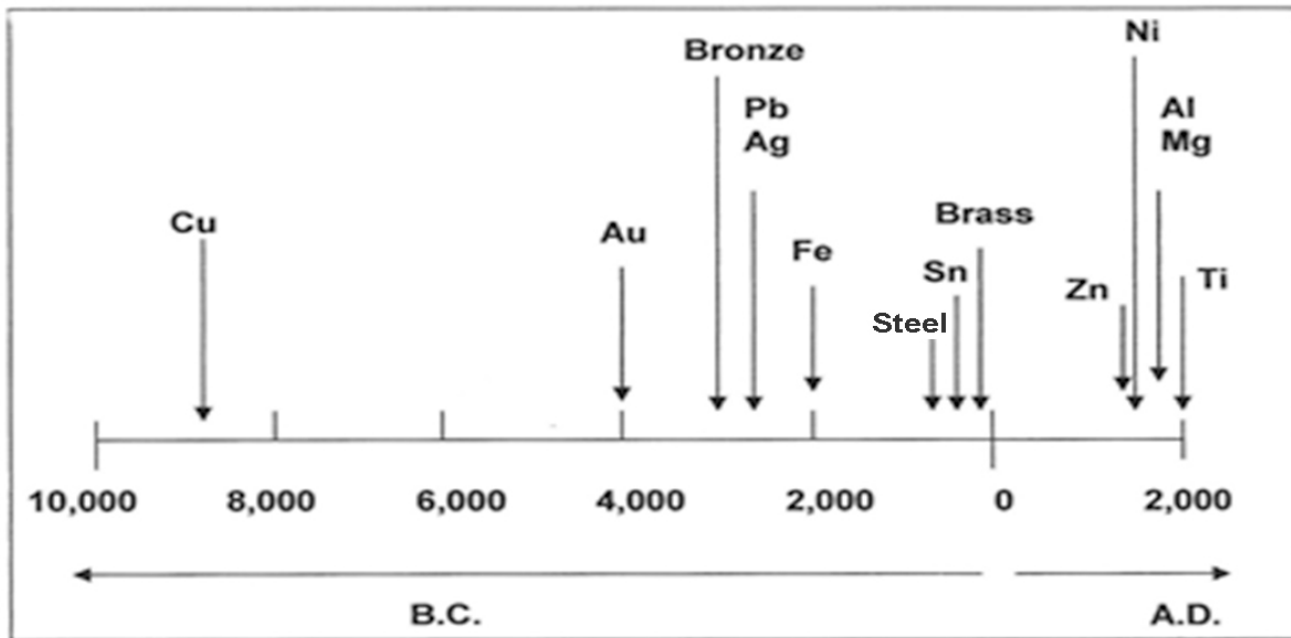


Figure 1 – Timeline for first commercial use of metals.

The name “Copper”

- § The symbol “Cu” comes from cuprum (Latin)
- § This is a foreshortened version of aes cyprum (metal from Cyprus)
- § In Greek, copper was “chalcos”
- § This period in time is the “chalcolithic”
 - means copper - stone

Periodic Table

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Mass (Weight) — 12.01115

Symbol — C

Atomic Number — 6

Period	IA		Transition Elements										GROUPS				VIIA	0	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1	1.00797 H																1.00797 H	4.0026 He	
2	6.939 Li	9.0122 Be											10.811 B	12.01115 C	14.0067 N	15.9994 O	18.9984 F	20.183 Ne	
3	22.9898 Na	24.312 Mg											26.9815 Al	28.086 Si	30.9738 P	32.064 S	35.453 Cl	39.948 Ar	
4	39.102 K	40.08 Ca	44.956 Sc	47.90 Ti	50.942 V	51.996 Cr	54.9380 Mn	55.847 Fe	58.9332 Co	58.71 Ni	63.54 Cu	65.37 Zn	69.72 Ga	72.59 Ge	74.9216 As	78.96 Se	79.909 Br	83.80 Kr	
5	85.47 Rb	87.62 Sr	88.905 Y	91.22 Zr	92.906 Nb	95.94 Mo	(99) Tc	101.07 Ru	102.905 Rh	106.4 Pd	107.870 Ag	112.40 Cd	114.82 In	118.69 Sn	121.75 Sb	127.60 Te	126.9044 I	131.30 Xe	
6	132.905 Cs	137.34 Ba	138.91 La	178.49 Hf	180.948 Ta	183.85 W	186.2 Re	190.2 Os	192.2 Ir	195.09 Pt	196.967 Au	200.59 Hg	204.37 Tl	207.19 Pb	208.980 Bi	(210) Po	(210) At	(222) Rn	
7	(223) Fr	(226) Ra	(227) Ac	Lanthanide Series										Actinide Series					
				140.12 Ce	140.907 Pr	144.24 Nd	(147) Pm	150.35 Sm	151.96 Eu	157.25 Gd	158.924 Tb	162.50 Dy	164.930 Ho	167.26 Er	168.934 Tm	173.04 Yb	174.97 Lu		
				232.038 Th	(231) Pa	238.03 U	(237) Np	(242) Pu	(243) Am	(247) Cm	(247) Bk	(249) Cf	(254) Es	(253) Fm	(256) Md	(254) No	(257) Lw		

Numbers in parentheses are mass numbers of the most stable or most common isotopes.

Copper - Properties

Symbol: Cu

Atomic Number: 29

Atomic Weight: 63.546

Standard state: solid at room temperature

Color: copper, metallic

Properties:

Ductile

Malleable

High thermal conductivity

High electrical conductivity

Easily alloyed

Good corrosion resistance

Readily available

Highly recyclable

Antimicrobial



Copper Production

Copper Production



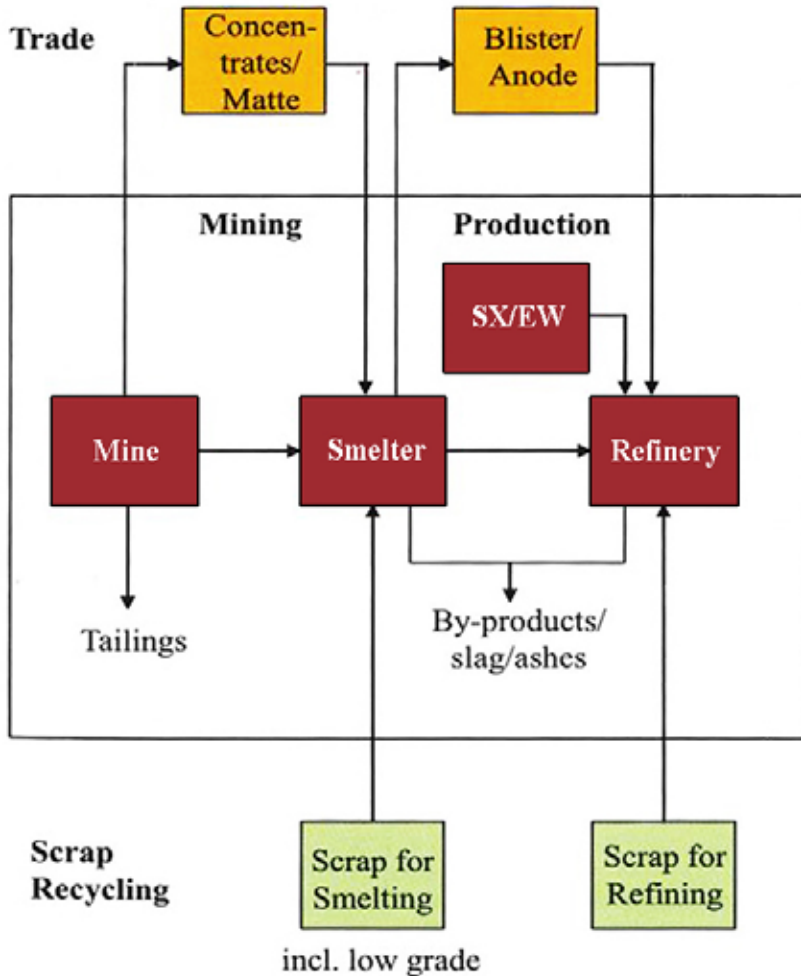
Copper Production - Ores

- § Two basic types of copper ores:
 - § sulfide ores
 - § Bornite, chalcocite and chalcopyrite
 - § oxide ores
 - § Malachite, azurite and chrysocolla



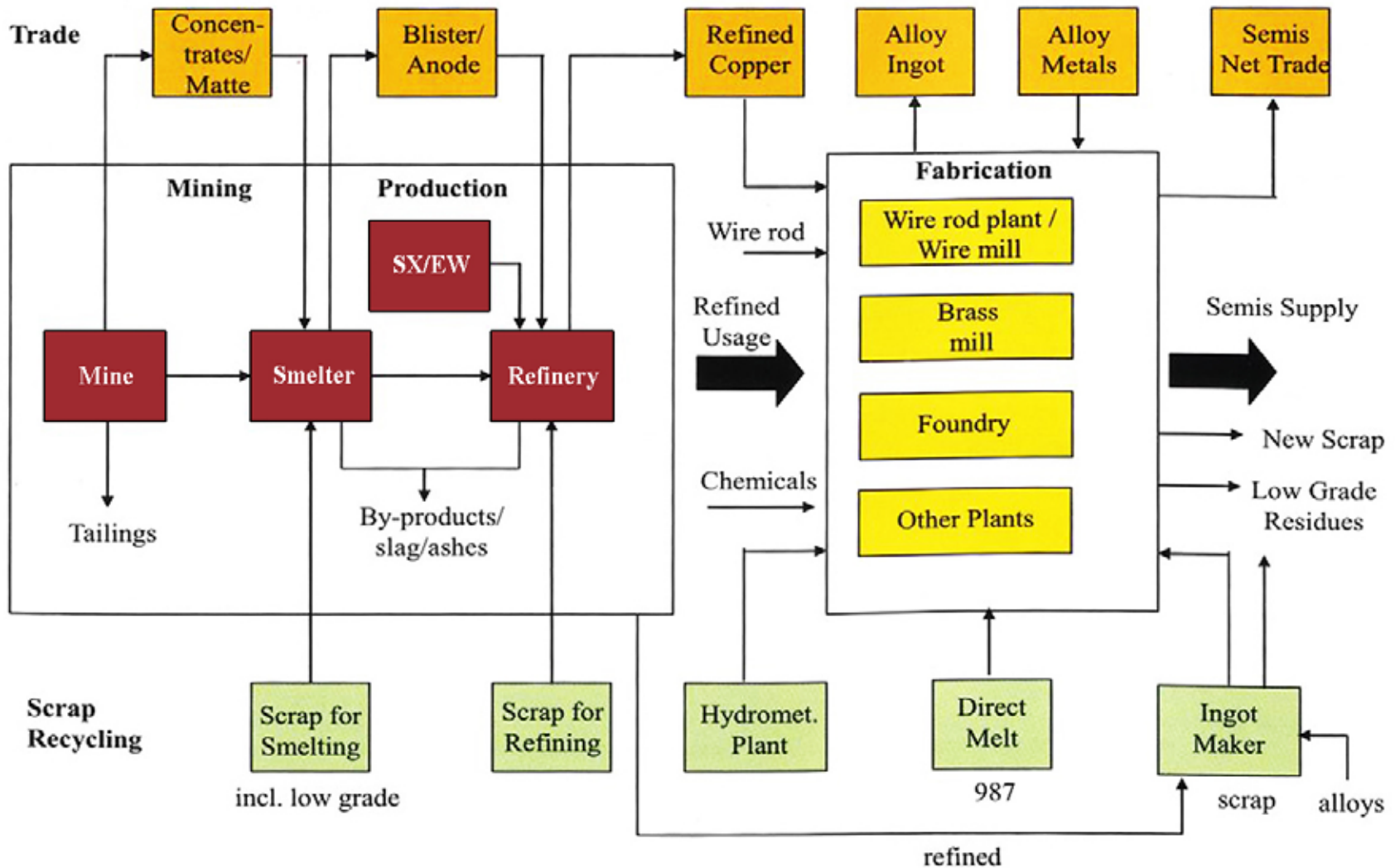
Copper Production and Recycling

Copper Recycling Flows



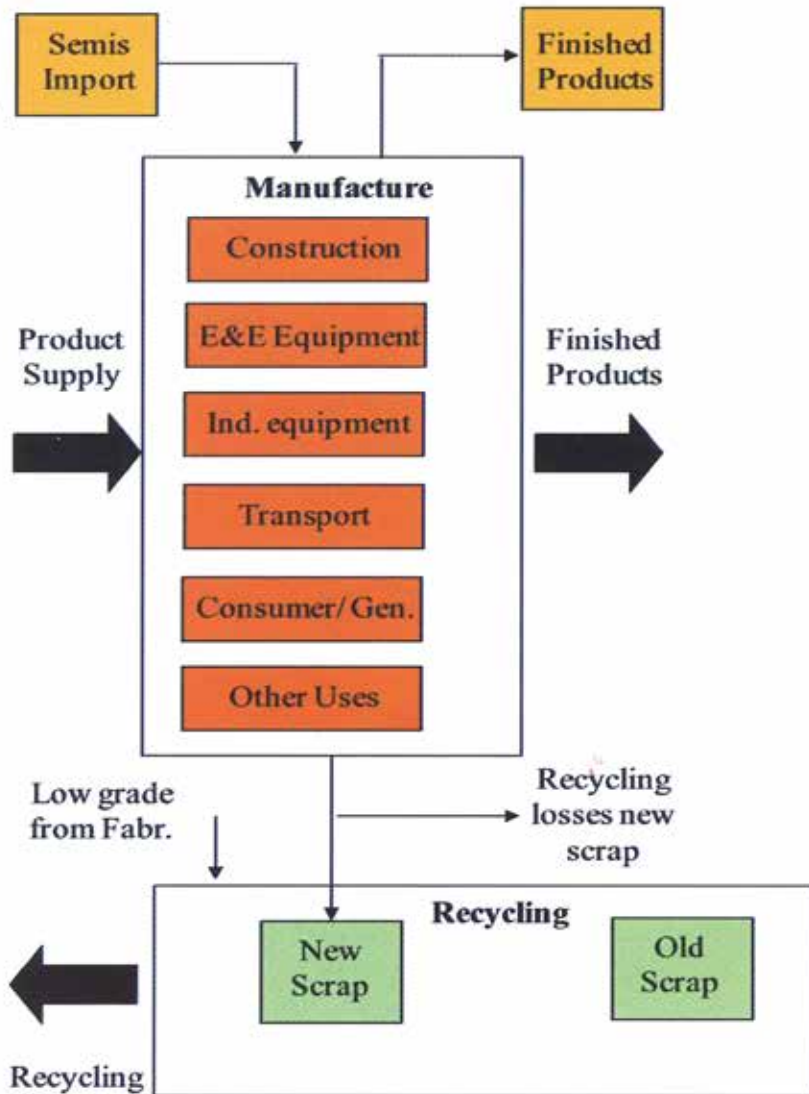
Copper Production and Recycling

Copper Recycling Flows



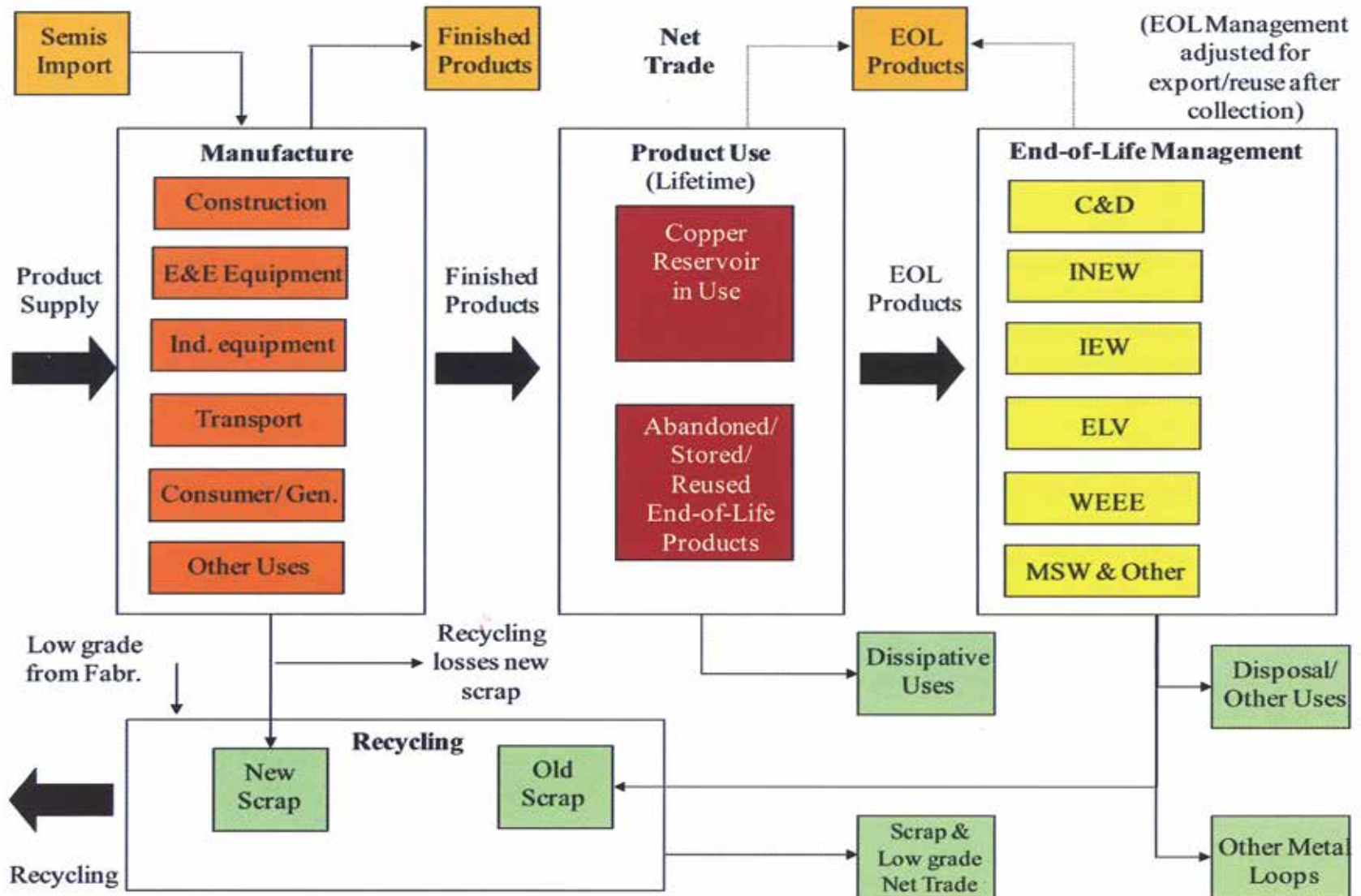
Copper Production and Recycling

Copper Recycling Flows



Copper Production and Recycling

Copper Recycling Flows



Reverberatory Melting Furnace

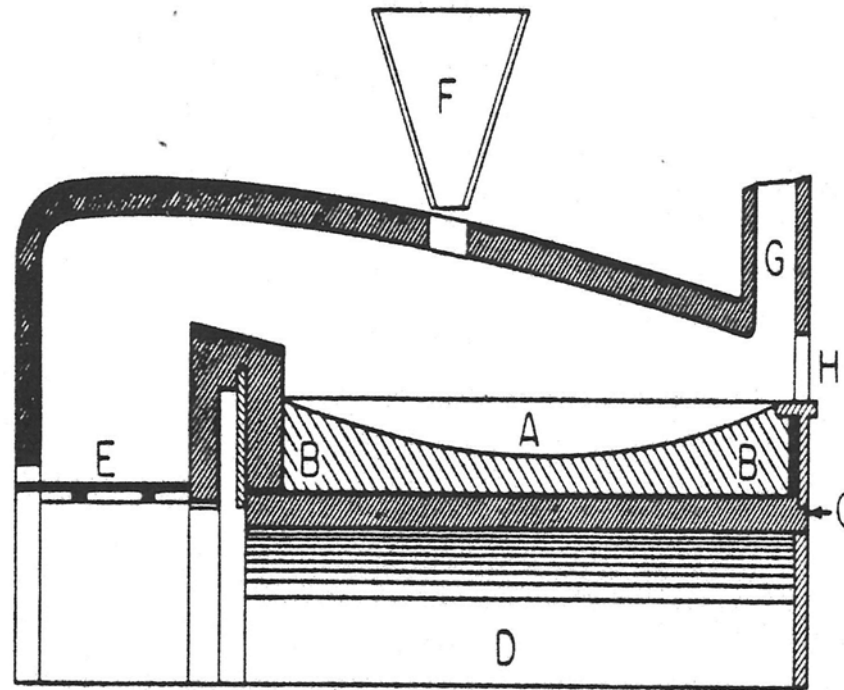


Fig. 1:17. Longitudinal Section of Melting Furnace (Reverberatory Type) as Used in Welsh Process.

Electric Arc Melting Furnace Types

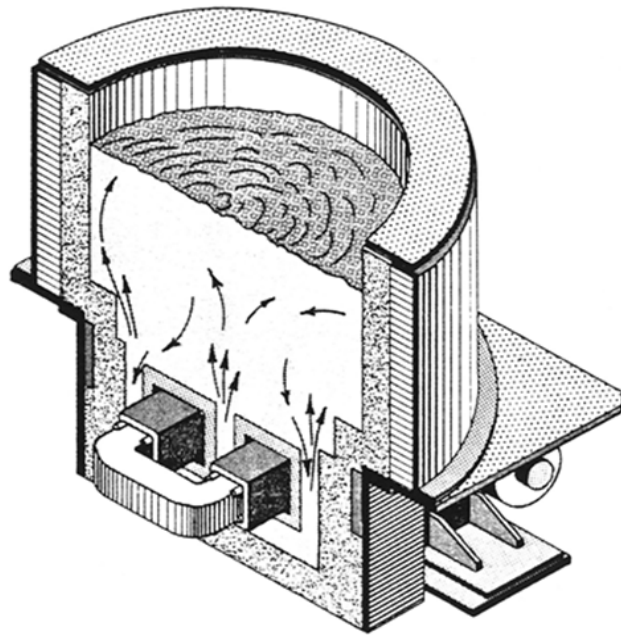


Fig. 4:3. Section Through Ajax-Tama-Wyatt Low Frequency Electric Induction Furnace.

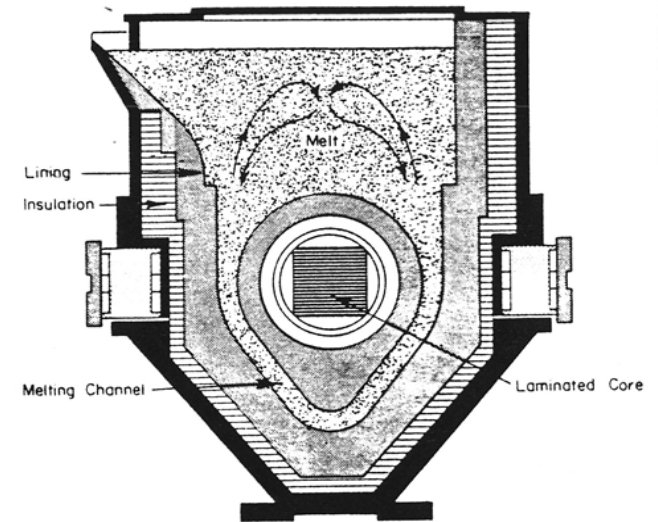
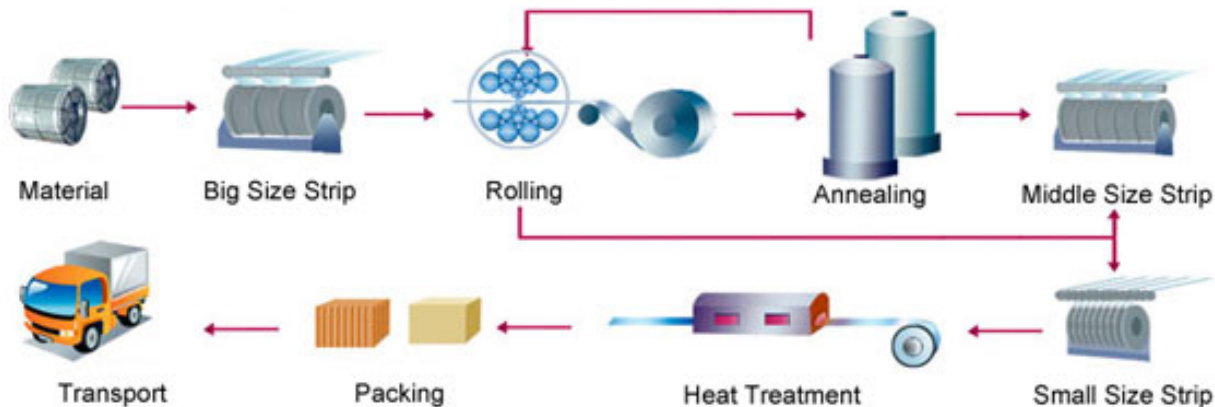
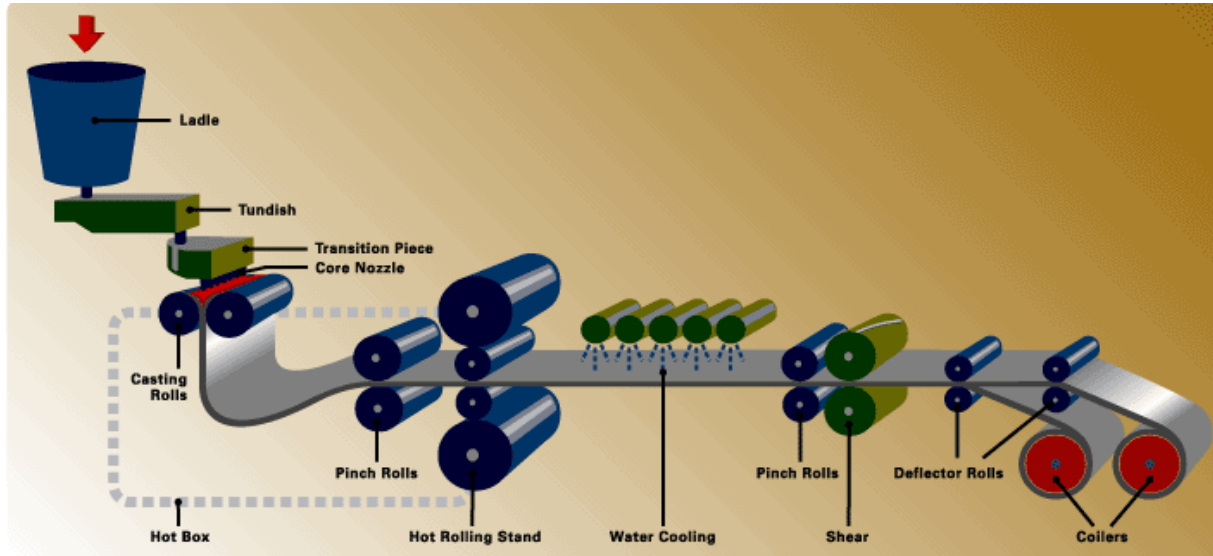


Fig. 4:2. Outline of Ajax-Wyatt Low Frequency Electric Induction Furnace.

A continuous production process (top) vs. a more conventional production process (bottom)



Development of Properties

Plastic Deformation and Temper

- § Metals are made up of crystals
- § Deformation of the crystal structure causes internal stress
 - § Internal stress in the crystals from rolling, drawing, etc.
 - § Temper is determined by processing parameters
- § Annealing relieves stresses

Plastic Deformation and Temper

§ Polycrystalline Metals

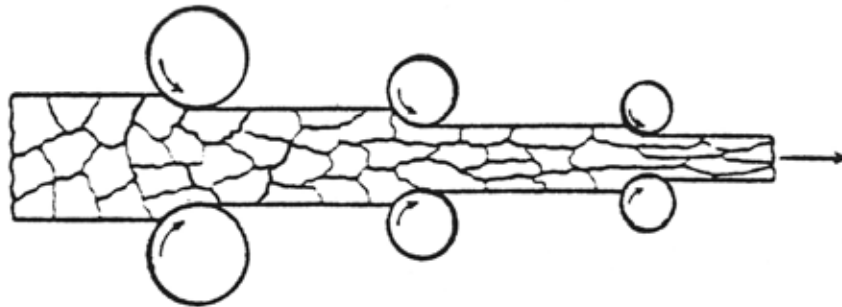


Figure 9.20 Schematic representation of elongation of grains during cold rolling.

As a net result the grains assume a preferred orientation and become elongated in the direction of flow.

Plastic Deformation and Temper

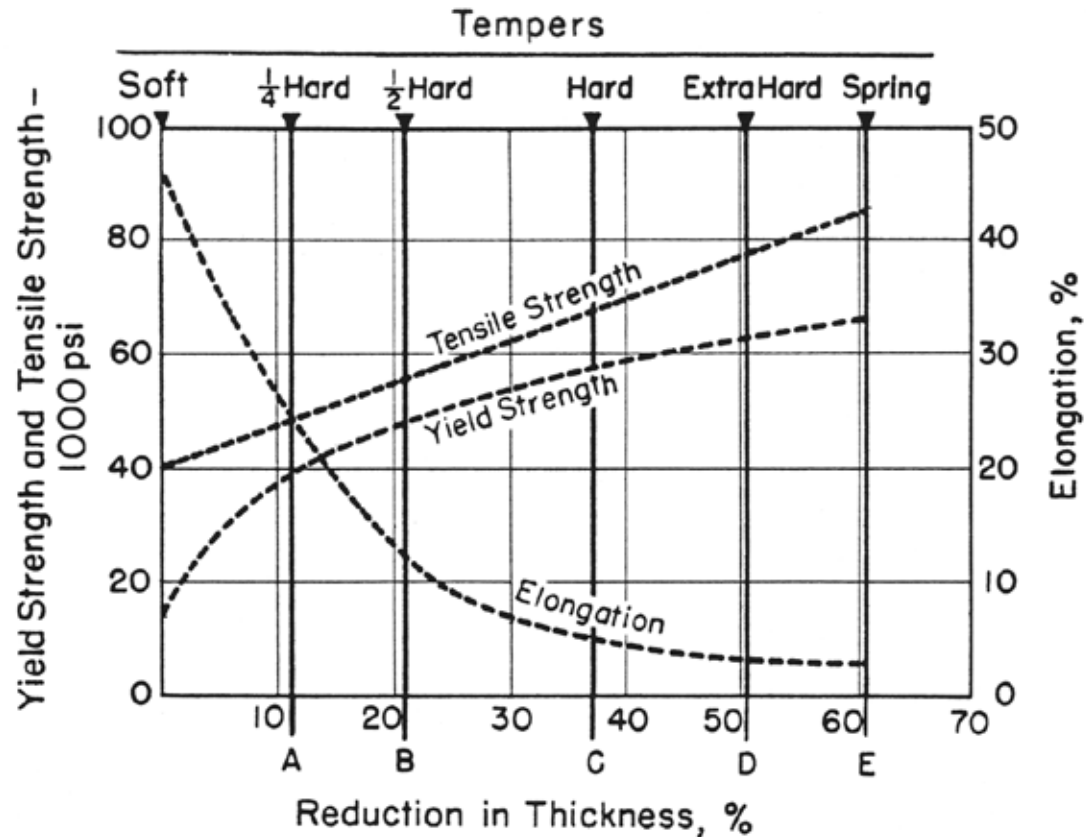


Fig. 10:12. Variation of Mechanical Properties with Percentage Reduction in Thickness of Red Brass.

Plastic Deformation and Temper

Table 7 Temper designations for wrought copper and brass based on cold reduction

Nominal temper designation	Rolled sheet			Drawn wire		
	Increase in B and S gage numbers	Reduction in thickness and area, %	True strain(a)	Reduction in diameter, %	Reduction in area, %	True strain(a)
¼ hard.....	1	10.9	0.116	10.9	20.7	0.232
½ hard.....	2	20.7	0.232	20.7	37.1	0.463
¾ hard.....	3	29.4	0.347	29.4	50.1	0.694
Hard	4	37.1	0.463	37.1	60.5	0.926
Extra hard	6	50.1	0.696	50.1	75.1	1.39
Spring	8	60.5	0.928	60.5	84.4	1.86
Extra spring	10	68.6	1.16	68.6	90.2	2.32
Special spring	12	75.1	1.39	75.1	93.8	2.78
Super spring.....	14	80.3	1.62	80.3	96.1	3.25

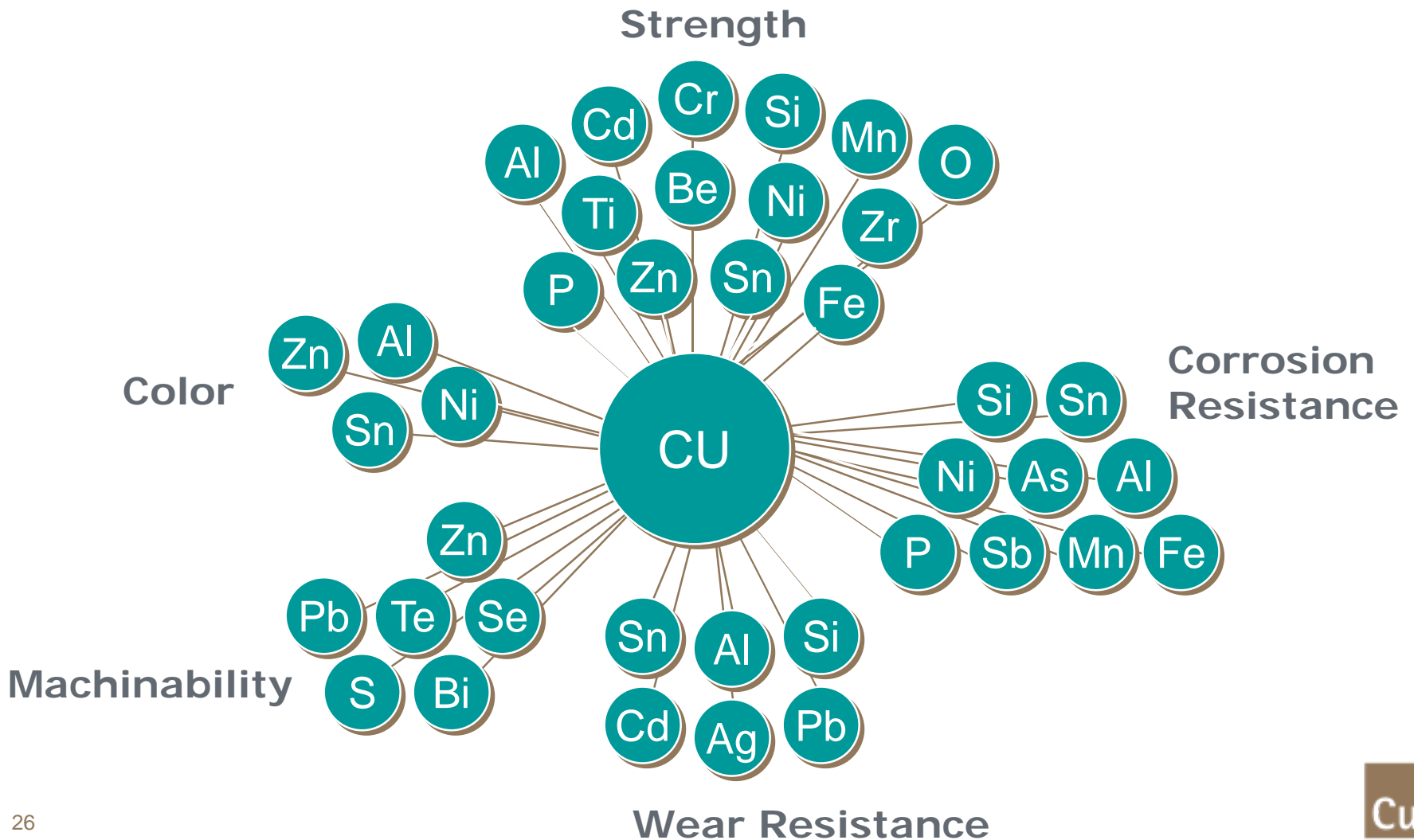
(a) True strain equals $\ln A_0/A$, where A_0 is the initial cross-sectional area and A is the final area.

Copper Alloys

Copper Alloy Designations

- § Unified Numbering System (UNS) Alloy Designations
- § UNS System begun in 1974
- § Originally only 3 numbers for an alloy
- § Now C plus 5 numbers
- § Wrought and Cast alloys are included
- § CDA Administers UNS Copper Alloys System

Copper Alloys



Wrought Copper Alloy Families

- § C100xx-C150xx Commercially Pure Cu
- § C151xx-C199xx Age Hardenable Cu (w/ Cd, Be, Cr, Fe)
- § C2xxxx Cu-Zn alloys – Brasses
- § C3xxxx Cu-Zn-Pb alloys – Leaded brasses
- § C4xxxx Cu-Zn-Sn alloys – Tin bronzes
- § C5xxxx Cu-Sn and Cu-Sn-Pb Phosphor bronze alloys
- § C6xxxx Cu-Al and Cu-Si Bronzes
- § C7xxxx Cu-Ni Copper Nickel and Cu-Ni-Zn Nickel Silver

Cast Copper Alloy Families

- § C800xx-C811xx Commercially Pure Coppers
- § C813xx-C828xx 95-99% Copper
- § C833xx-C899xx Cu-Zn alloys containing Sn, Pb, Mn, or Si
- § C9xxxx Other alloys, including tin bronze, aluminum bronze, copper nickel

Uses of Copper Alloys

Typical Uses of C11000 - Copper

Architectural

§ building fronts, downspouts, flashing, gutters, roofing, screening

Automotive

§ gaskets, radiators

Electrical

§ bus bars, conductivity wire, contacts, radio parts, switches, terminals

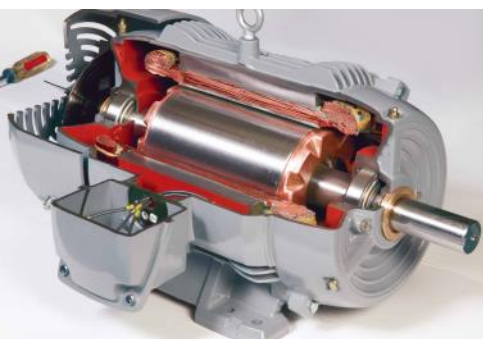
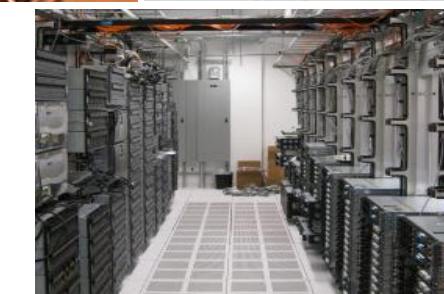
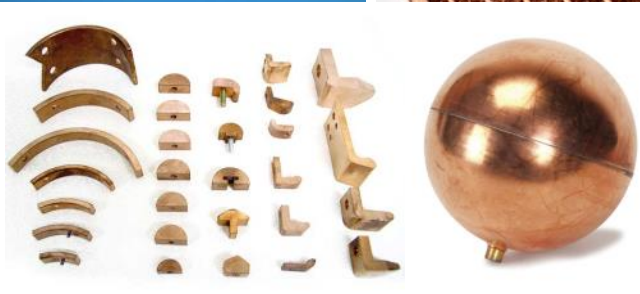
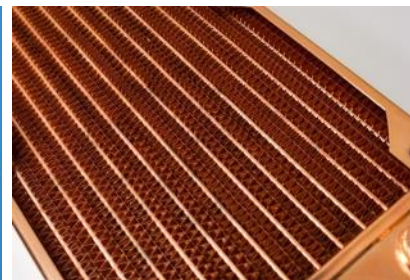
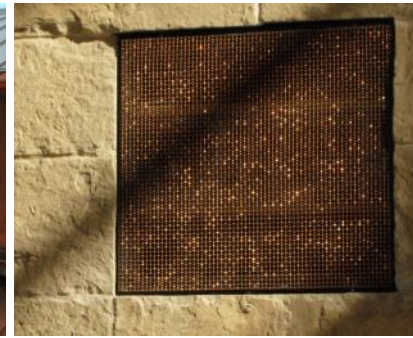
Hardware

§ ball floats, butts, cotter pins, nails, rivets, soldering copper, tacks

Miscellaneous

§ anodes, chemical process equipment, kettles, pans, printing rolls, rotating band, road bed expansion plates, vats

Typical Uses of C11000 - Copper



Typical Uses of C26000 - Cartridge Brass

Architectural

§ grillwork

Automotive

§ radiator and heater cores and tanks

Electrical

§ flashlight shells, lamp fixtures, switches, reflectors, screw shells, socket shells

Hardware

§ eyelets, fasteners, grommets, finish hardware articles (kick plates, lock sets, push plates, etc.)

Munitions

§ ammunition components

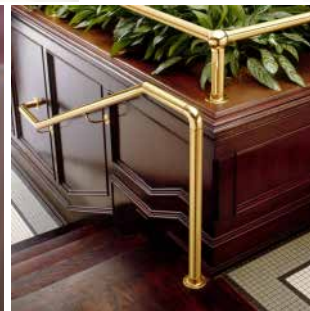
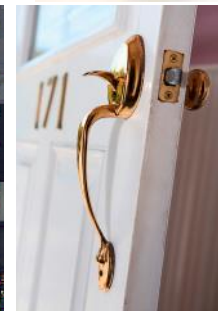
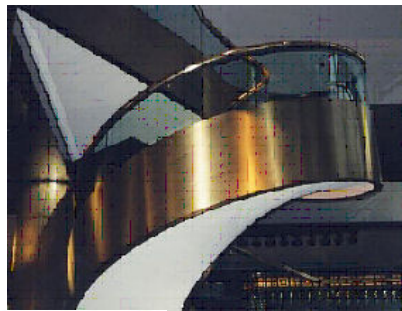
Plumbing

§ plumbing accessories, plumbing brass goods

Wire

§ fasteners, pins, rivets, screws, springs

Typical Uses of C26000 - Cartridge Brass



Typical Uses of C36000 - Free Machining Brass

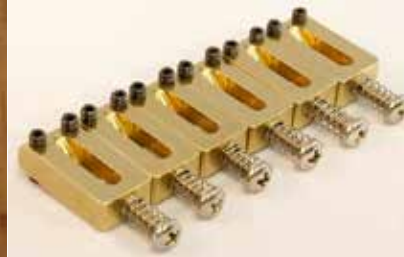
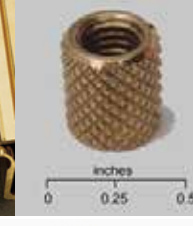
Hardware

§ gears, pinions

Industrial

§ automatic high speed screw machine parts (screws, bolts, nuts, miscellaneous fasteners)

Typical Uses of C36000 – Free Machining Brass



Typical Uses of C51000 - Phosphor Bronze

Architectural

§ bridge bearing plates

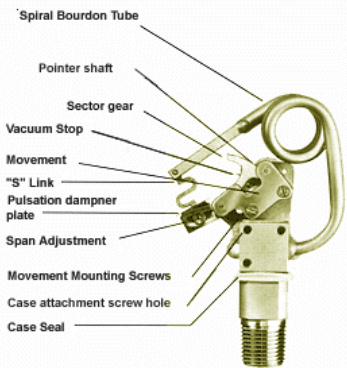
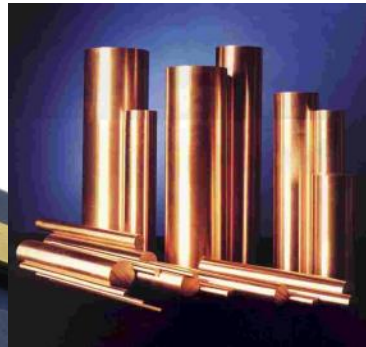
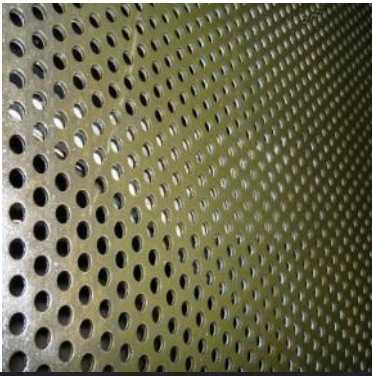
Hardware

§ beater bars, bellow, bourdon tubing, clutch disks, cotter pins, diaphragms, fuse clips, fasteners, lock washers, sleeve bushings, springs, switch parts, truss wire, wire brushes

Industrial

§ chemical hardware, perforated sheets, textile machinery, welding rods

Typical Uses of C51000 - Phosphor Bronze



Typical Uses of C70600 - Copper Nickel

Industrial

§ condensers, condenser plates, distiller tubes, evaporator and heat exchanger tubes, ferrules, salt water piping

Typical Uses of C70600 - Copper Nickel



Typical Uses of C75200 - Nickel Silver

Hardware

§ rivets, screws, table flat ware, truss wire, zippers

Miscellaneous

§ bows, camera parts, core bars, temples

Miscellaneous

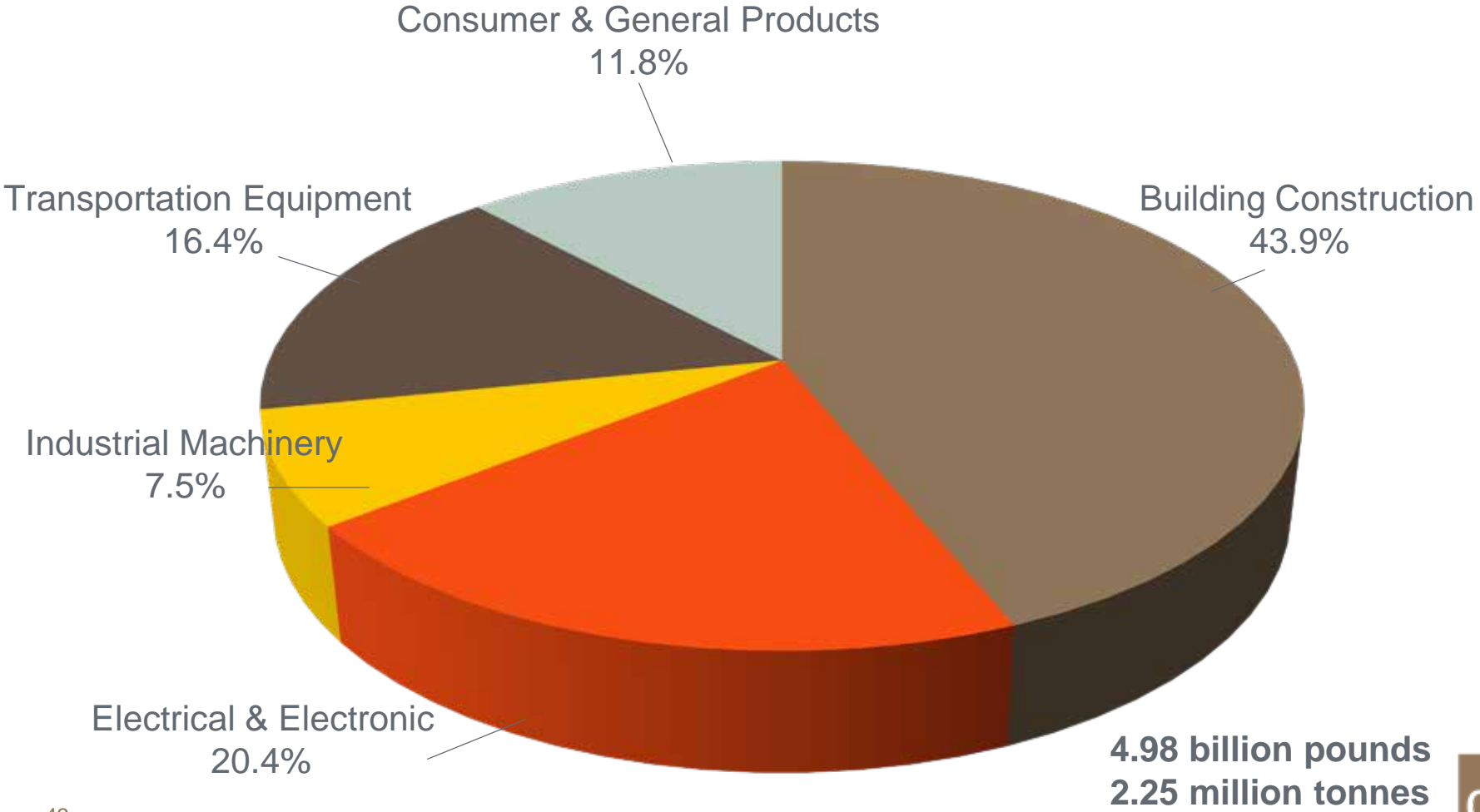
§ base for silver plate, costume jewelry, etching stock, hollow ware, name plates, radio dials

Typical Uses of Nickel Silver – C75200

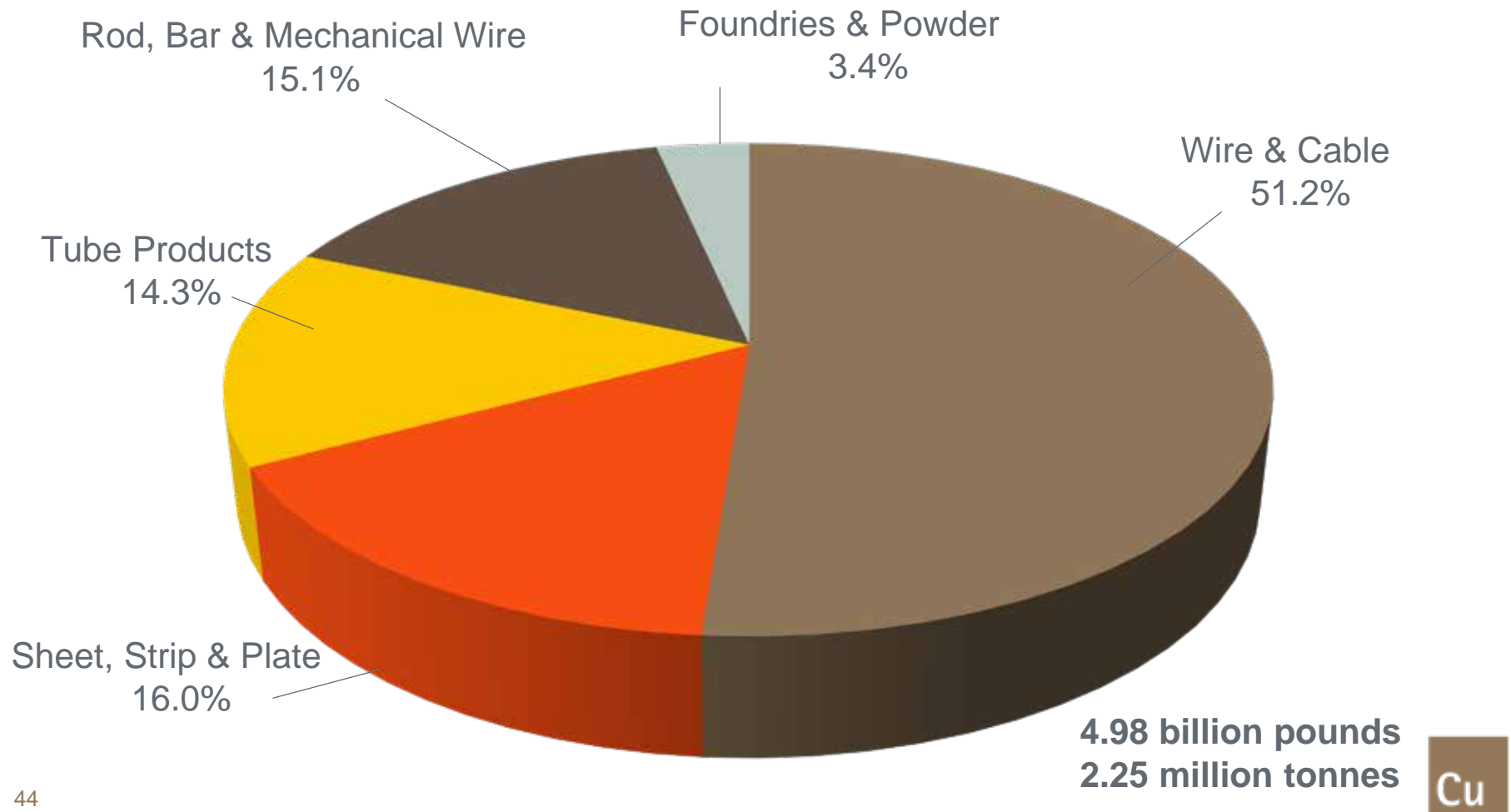


Overall Markets for Copper Materials

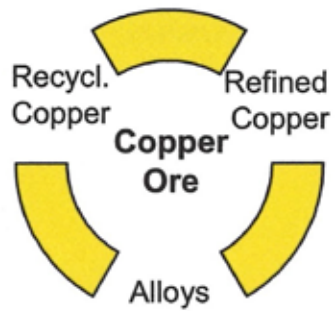
2011 Consumption – Markets

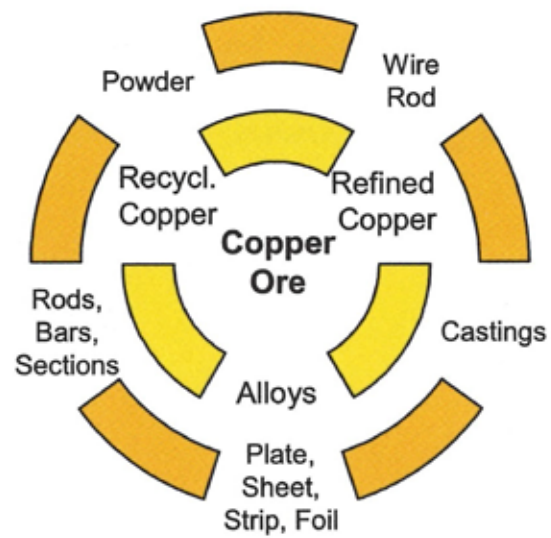


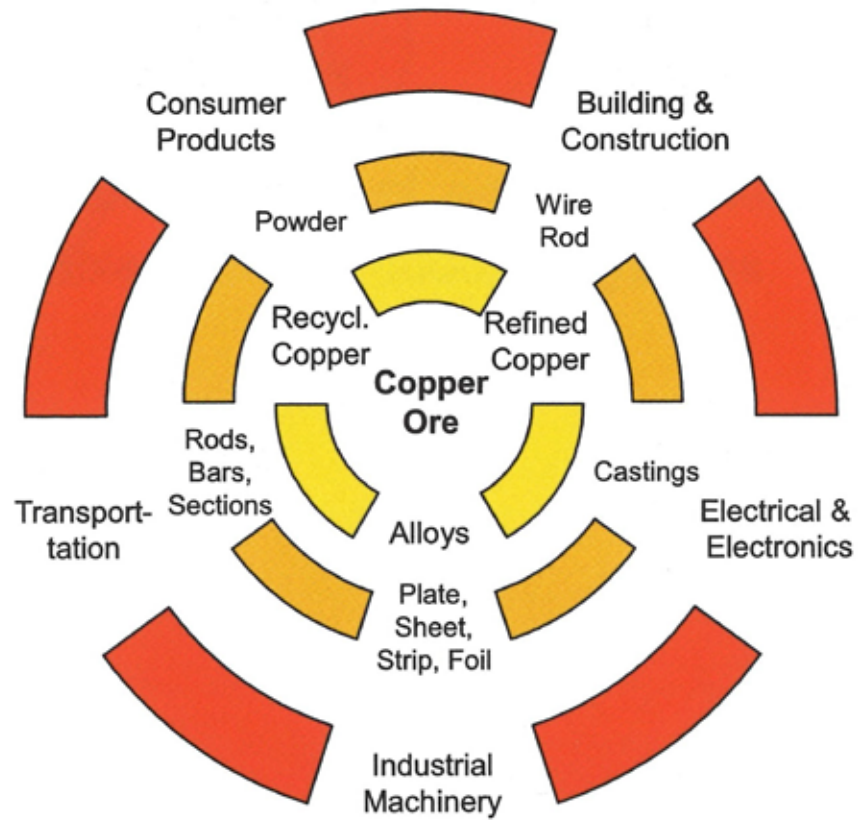
2011 Consumption – Products

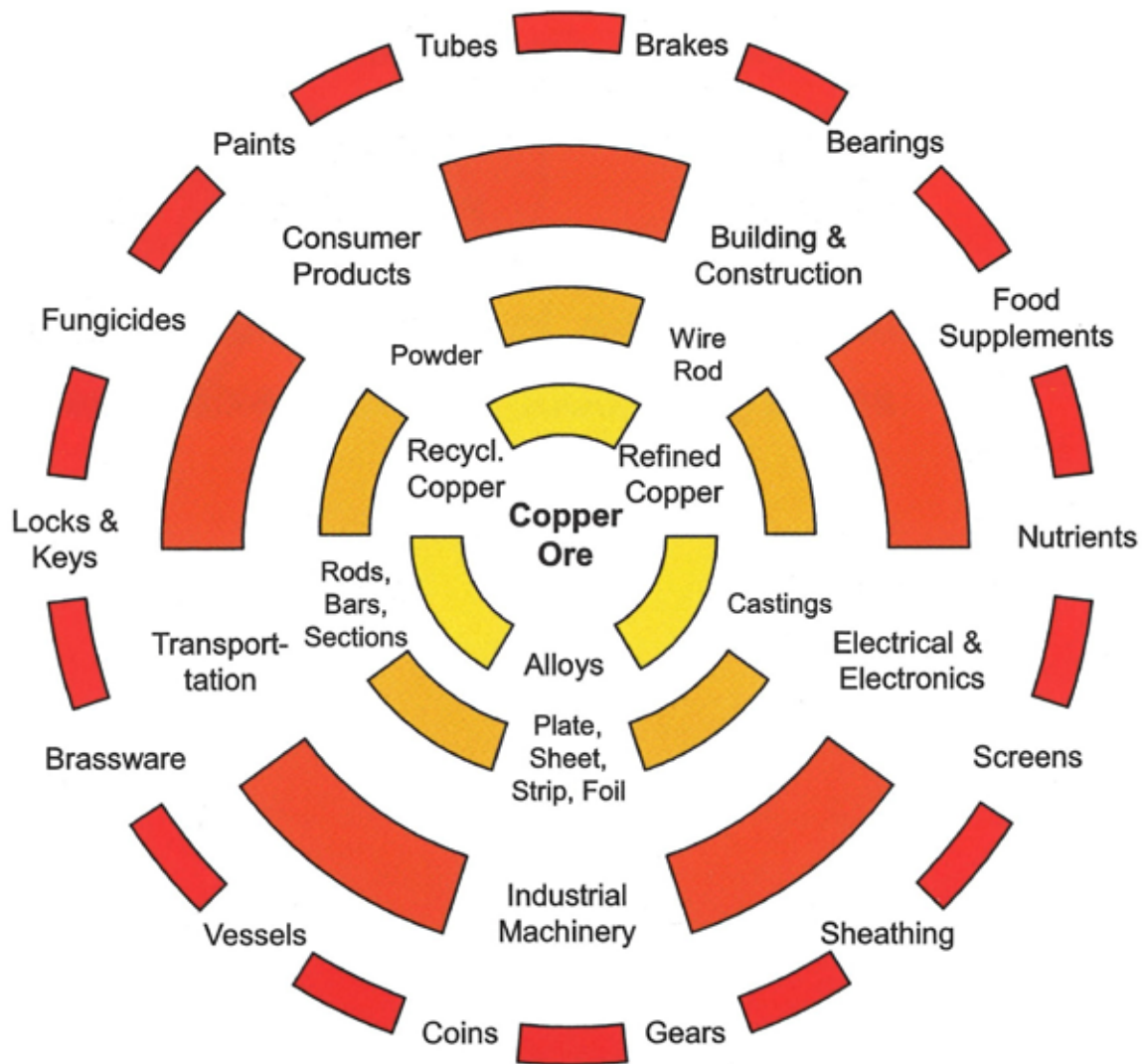


Summary











Thank you

For more information please contact

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