TECHNICAL INFORMATION ON

REVERE

COPPER AND COPPER ALLOYS

THIRD EDITION
AUGUST, 1946

REVERE COPPER AND BRASS INCORPORATED

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REVERE COPPER AND BRASS
INCORPORATED

Executive Offices: 230 Park Avenue
NEW YORK 17, NEW YORK

the skill and experience 145 years have built for Revere products

The high, recognized quality of Revere products is the result of the skill and experience developed by Revere in the 145 continuous years of fabricating its copper and copper alloy products. This uniform quality has been continually fostered by Revere ever since the first American copper rolling mill was established by Paul Revere in 1801.

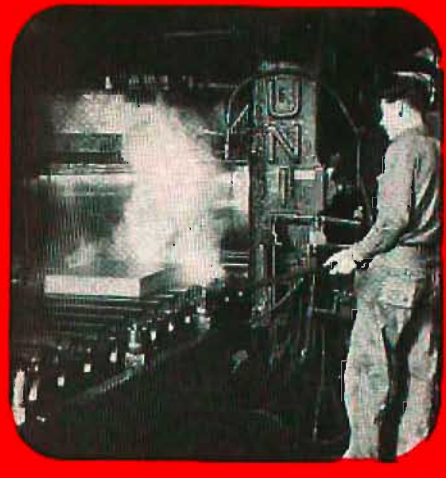
Today, Revere continues *quality* production. Modern mill equipment and rigid methods of control and inspection assure *both* excellence and uniformity of product. Thus, product designers, engineers and others—in specifying Revere metals—are assured of products built to give satisfactory performance under severe conditions . . . products backed by more than a century of technical progress.

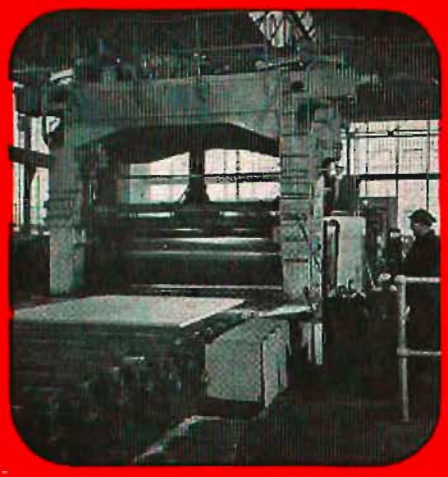
ever-widening application

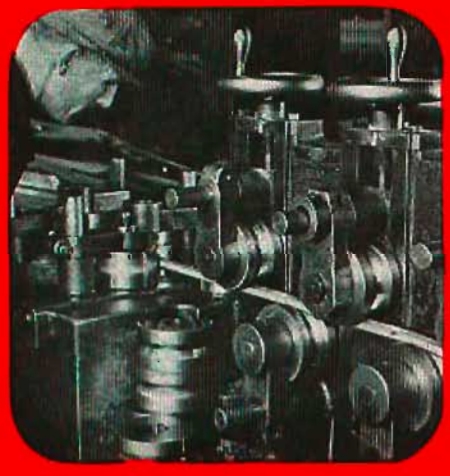
Today, Revere copper and copper-base alloys are finding ever-widening application in the improved products of American industry: compacts and clocks . . . doorknobs and dynamos . . . keys and kitchen utensils . . . mixers and motors . . . radiators and radar equipment . . . screws and silverware . . . toys and telephones. These products take full advantage of the uniquely varied properties of Revere metals: beauty, ductility . . . workability, formability, weldability . . . resistance to corrosion . . . heat and electrical conductivity . . . capacity for taking many finishes, natural or applied.

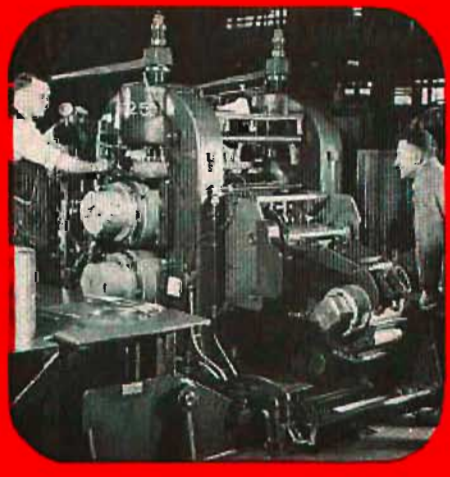
selection of correct material

The intelligent selection of the most suitable material for a given application is highly important, often difficult: many factors must be considered and balanced. To assist in specifying Revere products, this catalog is divided into seven sections. It gives the basic information on the more important Revere metals and their economical application. For engineering cooperation on specific projects, the Revere Technical Advisory Service (see back cover) is available without obligation.









Revere alloys

in this catalog:

Revere Coppers

Revere produces several types of copper for industrial and engineering applications. All types contain over 99% pure copper, but the presence of other elements in small controlled quantities makes each type especially suitable for specific applications.

advantages

While the physical properties of each type of copper vary, the basic qualities of copper remain. Electrolytic tough pitch and phosphorized types are the most widely used.

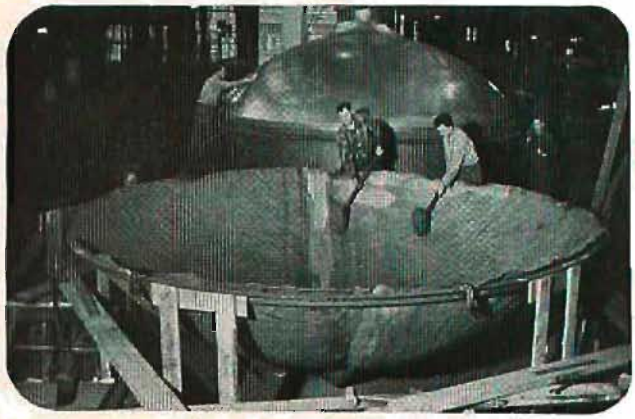
One of copper's most important qualities is its ability to resist corrosion. Significantly, copper withstands atmospheric corrosion as satisfactorily as any available commercial metal. Moreover, copper is substantially immune to the chemical attacks of a large number and variety of industrial chemicals. Copper, also, has high electrical and thermal conductivity. Copper is unsurpassed for its hot and cold working properties.

All the coppers, except the leaded coppers, are unusually plastic through a wide range of temperature. It is commercial practice to hot roll copper through a temperature range of 1200° to 1650°F. as this is the range of maximum plasticity. And copper, except the leaded coppers, may be hot worked by any of the commercial fabricating methods.

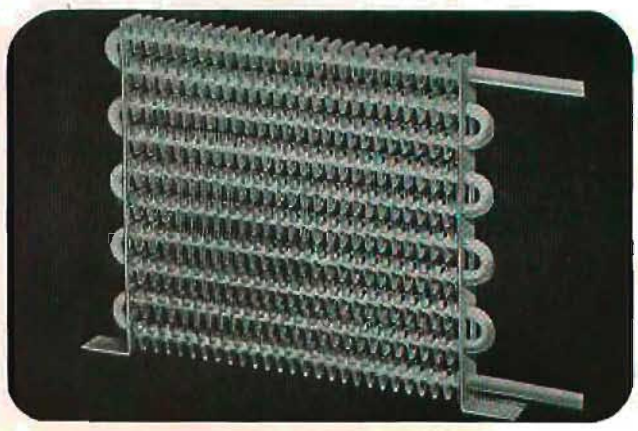
For cold working, the coppers possess almost unlimited capacity. It is common practice, in the manufacture of certain products, to achieve reductions of 90% without intermediate annealing.

Copper may be easily drawn, stamped and formed. It is easily soldered and polished. It is annealed at temperatures between 450° and 1500°F. depending upon the properties required. Most coppers can be welded by gas, carbon arc or metal arc methods.

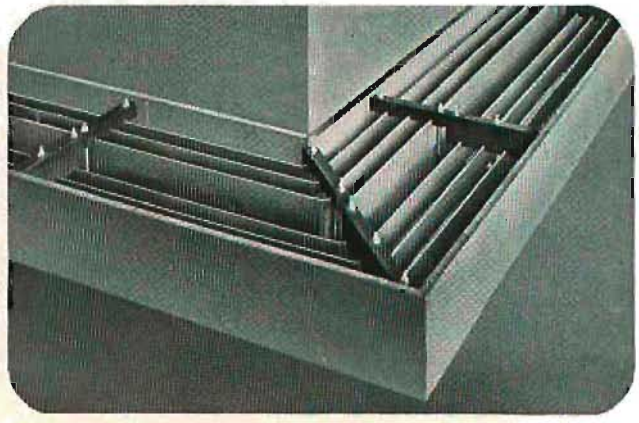
The table at right gives a quick guide to the Revere family of coppers.



Copper is readily worked. Here, coppersmiths beat out bottom of brew kettle from large copper sheets.



Copper transmits heat rapidly and uniformly, resists corrosion, defies rust, is easily worked



Copper is favored for bus bar and other electrical uses because of its high electrical conductivity.

alloy name	Electrolytic Tough Pitch		Phosphorized (Deoxidized)		Oxygen-free High Conductivity		Silver-bearing		Arsenical Phosphorized		Free-cutting Copper	
Revere alloy number	100		101		103		105		106		204	
composition: copper	99.9		99.9		99.96		99.9		99.46		99.75	
composition: silver	..		..		..		8-30 oz. per ton		..		..	
composition: arsenic	..		..		..		..		0.35		..	
composition: phosphor	..		0.025		..		..		0.025		Te 0.25	
typical uses	electrical equipment and conductors: bus bars, commutators, etc. architectural products: roofing, gutters, etc. process equipment: kettles, vats, distillery equipment forgings printing rolls		*in tube form:* water and refrigeration service heat exchange equipment oil burners, etc. *in sheet and plate:* welded construction		for special drawing and stamping for sealing to glass (electronic tubes) electrical equipment at high temperatures in presence of reducing gases		electrical commutators automotive radiators where retention of strength and moderately elevated temperatures are desired		certain condenser and heat exchange applications		screw machine parts electrical equipment welding torch tips interior vacuum tube parts	
general properties	high electrical conductivity high thermal conductivity excellent working ability		deoxidized higher forming and bending qualities than electrolytic copper (100) preferred for copper-smithing and welding (due to resistance to embrittlement at high temperatures		high electrical conductivity resistant to embrittling gases at high temperatures excellent for deep drawing, provides superior glass-to-metal seal		8 to 30 oz. silver per ton added to increase annealing (softening) temperature resists softening at temperatures from 500 to 700°F high conductivity		special resistance to certain corrosive media low electrical conductivity		similar to oxygen-free copper (103) but with free-cutting properties high electrical conductivity high thermal conductivity	
working properties: cold-working	excellent		excellent		excellent		excellent		excellent		good	
working properties: hot-working	excellent		excellent		excellent		excellent		excellent		good	
working properties: machining	fair		poor		poor		fair		poor		excellent	
working properties: welding▲	deoxidized copper preferred		gas, carbon arc, metal arc		carbon, metal arc		deoxidized copper preferred		gas, metal arc, carbon arc		not recommended	
working properties: soldering	excellent		excellent		excellent		excellent		excellent		good	
working properties: polishing	excellent		excellent		excellent		excellent		excellent		excellent	
density, lb per cu. in.	0.322		0.323		0.323		0.322		0.323		0.323	
Young's modulus of elasticity, psi (000,000 omitted)	16.0		16.0		16.0		16.0		16.0		16.0	
melting point, °F	1981		1981		1981		1981		1976		1981	
average coefficient of thermal expansion, per °F (68 to 570°F)	0.0000098		0.0000098		0.0000098		0.0000098		0.0000096		0.0000098	
electrical conductivity, % IACS at 68°F	100 min		75 to 90		100 min		100 min		45		98	
thermal conductivity, Btu, per sq ft, per ft, per hr, per °F, at 68°F	227		175 to 205		227		227		102		227	
	hard	***soft***	***hard***	***soft***	***hard***	***soft***	***hard***	***soft***	***hard***	***soft***	***hard***	***soft***
tensile strength psi (000 omitted): sheet ■	50	30	55	30	50	32	52	33	..	..	..	..
tensile strength psi (000 omitted): rod ●	45	32	..	..	..	..	..	..	..	..	53	32
tensile strength psi (000 omitted): tube ○	..	..	59	35	37	..	..	..	60	37	..	..
elongation, % in 2 in.: sheet ■	5	40	5	40	5	40	5	40	..	..	..	..
elongation, % in 2 in.: rod ●	20	50	..	..	..	..	..	..	..	..	7	40
elongation, % in 2 in.: tube ○	..	..	5	45	..	..	..	..	4	42	..	..
yield strength, 0.5% extension, psi (000 omitted): sheet ■	42	7.5	42	75	48	8	48	7	..	..	..	..
yield strength, 0.5% extension, psi (000 omitted): rod ●	42	10	..	..	..	..	..	..	..	..	49	7
yield strength, 0.5% extension, psi (000 omitted): tube ○	..	..	48	8	..	..	..	..	48	8	..	..
Rockwell hardness: sheet ■	50B	40F	50B	40F	50B	40F	55B	40F	..	..	..	..
Rockwell hardness: rod ●	45B	25F	..	..	..	..	..	..	..	..	48B	40F
Rockwell hardness: tube ○	..	..	96F	30F	..	..	..	..	95F	23F	..	..
ASTM specifications: sheet, strip	B101 B152	B11 ..	B101 B152	B11 ..	B101 B152	..	B101 B152	.. ..	..	..	..	..
ASTM specifications: rod	B12 B49 B124	B133 B187 B48	B12 B124 ..	B133 B48 ..	B12 B49 B124	B133 B187 B48	B49 B133 ..	B187 B48 ..	..	..	..	..
ASTM specifications: tube	B13 B111 ..	B188	B13 B42 B68	B75 B88 B111	B13 B68 B75	B111 B188 ..	B13 B188 ..	B42 B68 B88 B75 ..	B13 B42	B75 ..	..	..
for further data, see	*page 6*		*page 9*		*page 9*		*page 8*		*page 8*		....	

▲ by fusion methods: conductivity of the coppers makes resistance welding (spot and seam) impractical. Coppers, however, may be resistance brazed by a patented method.

● basis of rating: *hard*, on final area reduction of 25%; *soft*, on final grain size of 0.035 mm. (all tests on rod under 1-inch diameter.)

■ basis of rating: *hard*, on material previously rolled 4 B & S numbers hard (37.5% area reduction); *soft*, on final grain size of 0.035 mm. (all tests conducted on 0.040 in. stock.)

○ basis of rating: *hard*, on material previously extruded and cold drawn to 0.750 in. o.d. by 0.049 in. wall; *soft*, on same material after 1-hour anneal at 1200°F.

Electrolytic Copper

alloy no. 100 • tough pitch

copper 99.90% minimum

forms available: sheet, strip, plate, rod, bus bar, tube, forgings

general properties • Revere Electrolytic Copper combines high electrical conductivity and high thermal conductivity with excellent working ability. It has excellent corrosion resistance and is immune to the chemical attack of a large number of industrial chemicals.

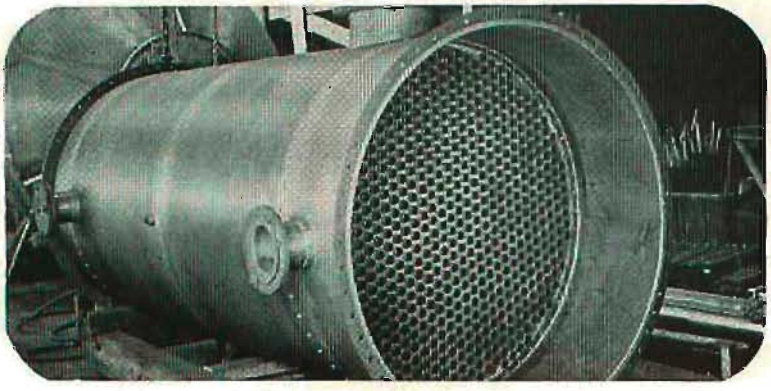
typical uses • Electrolytic Copper is recommended for electrical equipment and conductors (bus bars, commutators, etc.); architectural products (roofing, gutters, etc.); process equipment (kettles, vats, distillery equipment); forgings, printing rolls.

physical properties (sheet and strip)	hard ■	soft □
tensile strength, psi (000 omitted)	50	30
elongation, % in 2 in.	5	40
yield strength, 0.5% extension, psi (000 omitted)	42	7.5
Rockwell hardness	50B	40F
density, lb per cu in.	0.322	
average coefficient of thermal expansion, per °F, (68 to 570°F)	0.0000098	
electrical conductivity, % IACS, at 68°F	100 min	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	227	

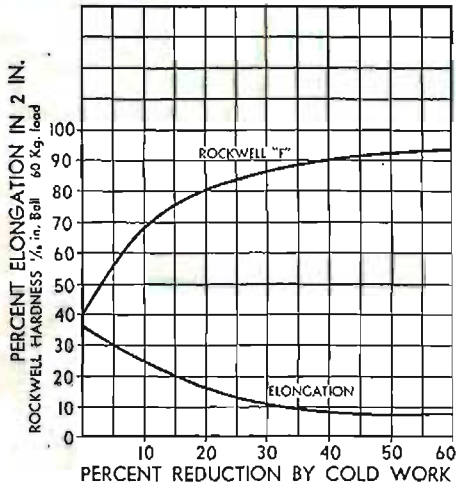
■ based on material previously rolled four B&S numbers hard (37.5% area reduction)
□ based on grain size of 0.035 mm.
All tests conducted on 0.040 in. stock.

working properties • Cold-working, hot-working, soldering, polishing—excellent. Machining—fair. Welding—deoxidized copper preferred.

ASTM specifications • Sheet: B152. Rod: B124, B133

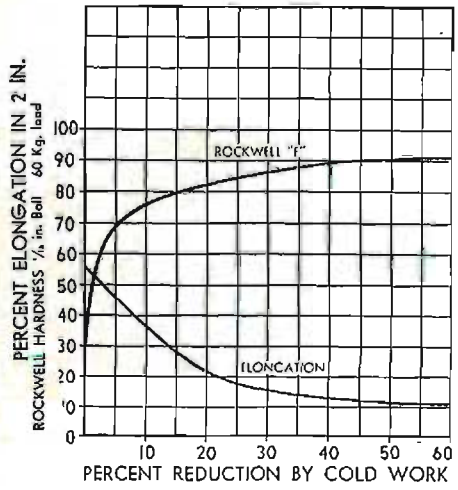


sheet cold working



Rockwell F hardness, elongation of Electrolytic Copper strip previously annealed to grain size of 0.045 mm

rod cold working



Rockwell F hardness, elongation of Electrolytic Copper rod previously annealed to grain size of 0.030 mm.

Silver-bearing Copper

alloy no. 105

silver 8 to 30 oz. per ton *copper 99.9% min.*

forms available: sheet, strip, rod, tube

general properties • Revere Silver - bearing Copper contains from 8 to 30 ounces of silver per ton to resist softening at temperatures from 500° to 700°F and possesses high conductivity.

typical uses • Recommended for products that are subjected to high temperatures because the silver content raises annealing temperature.

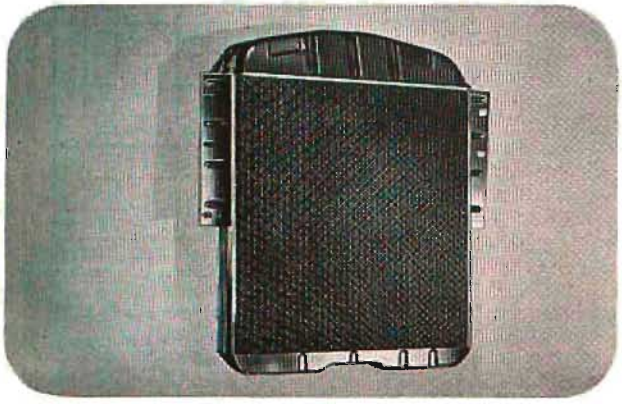
physical properties (strip)	hard ■	soft □
tensile strength, psi (000 omitted)	52	33
elongation, 5% in 2 in.	5	40
yield strength, 0.5% extension, psi (000 omitted)	48	7
Rockwell hardness	55B	40F
density, lb per cu in.	0.322	
average coefficient of thermal expansion, per °F, (68 to 570°F)	0.0000098	
electrical conductivity, % IACS, at 68°F	100 min	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	227	

■ based on material previously rolled four B&S numbers hard (37.5% area reduction)
□ based on grain size of 0.035 mm.
All tests conducted on 0.040 in. stock.

working properties • Cold working, hot working, soldering, polishing—excellent. Machining —fair. Welding—not recommended.

ASTM specifications

sheet: B101, B152
rod: B49, B133, B187
tube: B13, B188



Arsenical Copper

alloy no. 106

copper 99.45% *arsenic 0.35%* *phosphor 0.025%*

available in tube form only

general properties • Revere Arsenical Phosphorized Copper has low electrical conductivity and is resistant to certain corrosive media.

typical uses • This copper is recommended for certain condenser and heat exchanger applications.

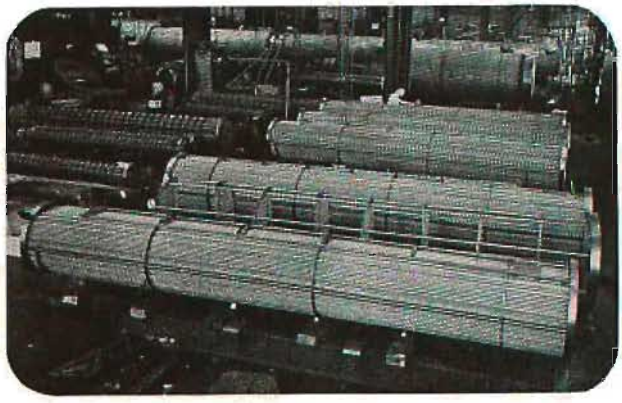
physical properties (tube)	hard ■	soft □
tensile strength, psi (000 omitted)	60	37
elongation, % in 2 in.	4	42
yield strength, 0.5% extension, psi (000 omitted)	48	8
Rockwell hardness	95F	28F
density, lb per cu in.	0.323	
average coefficient of thermal expansion, per °F (68 to 570°F)	0.0000096	
electrical conductivity, % IACS, at 68°F	45	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	102	

■ based on material previously extruded and cold drawn to 0.750 in. od by 0.049 in. wall.
□ based on material after a 1-hour anneal at 1200°F.

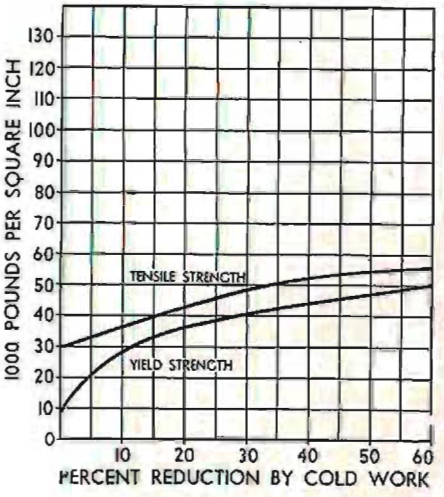
working properties • Cold-working, hot-working, soldering, polishing—excellent. Machining —fair. Welding—see page 54.

ASTM specifications

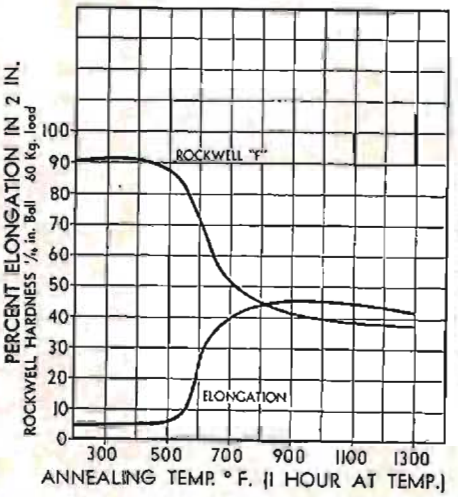
tube: B13, B42, B75



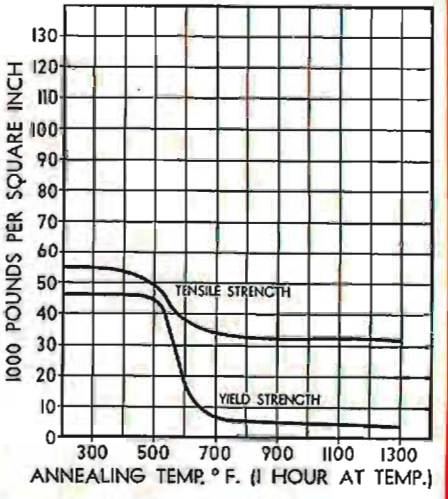
annealing



tensile strength, yield strength (0.5%) of Electrolytic Copper strip previously annealed to grain size of 0.045 mm.

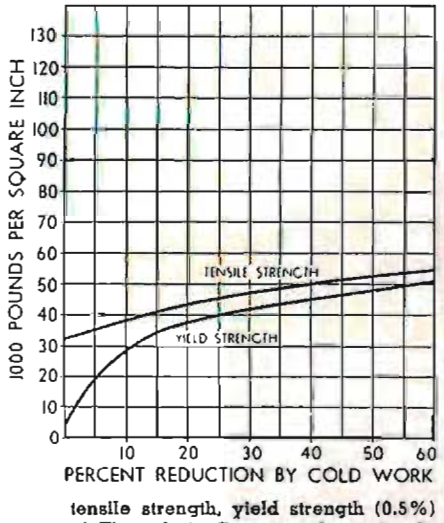


Rockwell F hardness, elongation of Electrolytic Copper strip previously cold rolled 50% from grain size of 0.045 mm.

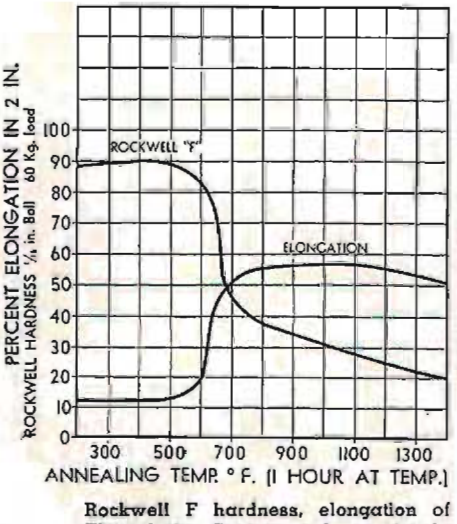


tensile strength, yield strength (0.5%) of Electrolytic Copper strip previously cold rolled 50% from grain size of 0.045 mm.

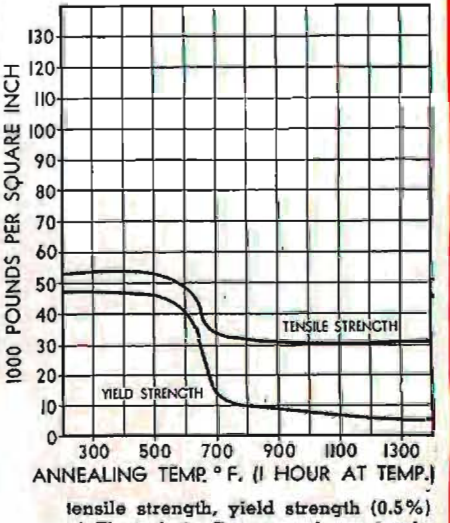
annealing



tensile strength, yield strength (0.5%) of Electrolytic Copper rod previously annealed to grain size of 0.030 mm.



Rockwell F hardness, elongation of Electrolytic Copper rod previously cold worked 50% from grain size of 0.030 mm.



tensile strength, yield strength (0.5%) of Electrolytic Copper rod previously cold worked 50% from grain size of 0.030 mm.

→ the charts at small scale on these pages are intended to indicate range of properties and not to present exact data.

Revere Brasses

alloys of copper and zinc

characteristics

The Revere brasses merit special attention; they offer a combination of unusual properties for the production of a wide variety of *stamped, drawn* and *spun* articles. Moreover, the ultimate cost is often lower than with other materials because, even though the initial per-pound price may appear high, the finishing costs are usually lower—especially where buffed or plated surfaces are required.

high ductility • High ductility and malleability of the copper-zinc alloys (brasses) effect savings in time and cost because deeper draws in one operation are possible: a smaller number of operations are required to finish a piece to size and dimension. Because of the low work-hardening rate, a combination of forming processes is frequently possible in making intricate shapes, without the need for intermediate annealing.

low annealing • If annealing is required the temperatures are low, usually not over 1100°F. This means lower fuel cost.

fast drawing • Rapid drawing speeds are permissible. This is particularly desirable for repetition press work or in other operations where parts are produced in large quantities. Power consumption is relatively low.

non-fouling of dies • Some metals or alloys foul the dies quickly. Brasses do not. Only a minimum of die redressing is therefore needed.

high scrap value • Scrap naturally results from practically any stamping or forming operation. Significantly, the scrap resale value of the brasses, as well as of copper and other copper-base alloys, is high. This reduces the overall cost of finished parts.

good plating base • Many products require plating for both protection and appearance. To prevent "spotting out", under-plates are necessary. One method is to under-plate the brass with copper. If chrome is to be the finished plate, it is customary to under-plate with nickel. Brass plates well and polishes easily. Moreover, nearly all platings are more or less porous, so the brasses, with excellent corrosion resistance, have many marked advantages when used as the base metal for plated finishes.

pleasing color • Today, more than ever, color is an important design factor. And brasses offer a wide range of warm colors . . . from the almost copper color of those low in zinc through the gold tones to the characteristic yellow brass color of those containing larger amounts of zinc. Alloys containing about 15% zinc are noted for their rich, golden color and are frequently used to imitate gold.

composition

Brasses are essentially alloys of copper and zinc. Within the commercial range of copper-zinc alloys, the zinc content is completely soluble in the copper in all proportions.

brasses for cold-working • Alloys of copper and zinc containing up to 36% of zinc are known as *alpha* brasses. They have unusually good cold-working properties and general resistance to corrosion.

As zinc is added to copper, alloys are produced with increasingly higher tensile strength but with lowered electrical and thermal conductivity. Alloys having a composition range of 65 to 70% copper possess the best combination of strength and ductility and are used widely for the manufacture of articles requiring extreme cold-working.

brasses for hot-working • As the zinc content is increased beyond approximately 35%, a second copper-zinc solid solution, richer in zinc than the alpha solid solution, is formed. This second phase is known as *beta* and alloys of copper and zinc containing from 36 to 45% of zinc are known as *alpha-beta* brasses. Alloys containing 45% of zinc are richer in beta than those containing 36% zinc. The amount of zinc content has a distinct effect on the hot-working characteristics of the mixture; the best qualities are obtained when the quantity of zinc is about 40%.

Alpha-beta brasses are characterized by their good hot-working properties. Excellent hot-working properties combined with high strength are found in alloys having 36 to 40% zinc content. In these mixtures, the beta constitutent is effective in hardening and strengthening the alloy.

temper

Temper is produced in brass by cold-working operations. Unlike many of the ferrous metals, it is not possible to harden or increase the temper of the brasses of the alpha type by means of quenching or special heat treatment.

The degree of hardness or temper of alloys in sheet, roll or strip form is designated in the mill by stating

Phosphor Deox. Copper

alloy no. 101

phosphorus 0.025% *copper 99.9%*

forms available: sheet, strip, rod, tube

general properties • Revere Phosphor-deoxidized Copper has higher forming and bending qualities than Electrolytic Copper. Moreover, it is generally preferred for welding applications because at welding temperatures it resists embrittlement by reducing gases.

typical uses • This copper, in tube form, is recommended for water and refrigeration service, heat exchanger equipment and oil burners. In sheet and plate form, it is recommended for welded constructions.

physical properties (tube)	hard ■	soft □
tensile strength, psi (000 omitted)	59	35
elongation, % in 2 in.	5	45
yield strength, 0.5% extension, psi (000 omitted)	48	8
Rockwell hardness	96F	30F
density, lb per cu in.	0.323	
average coefficient of thermal expansion, per °F (68 to 570°F)	0.0000098	
electrical conductivity, % IACS, at 68°F	75-90	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	175-205	

■ based on material previously extruded and cold drawn to 0.750 in. od by 0.049 in. wall

□ based on material after a 1-hour anneal at 1200°F

working properties • Cold working, hot working, soldering, polishing—excellent. Machining—fair. Welding—see page 54.

ASTM specifications

sheet, strip: B101, B152
rod: B12, B124, B133
tube: B13, B42, B68, B75, B88, B111

Oxygen-free Copper

alloy no. 103

copper 99.9%

forms available: sheet, strip, rod, tube

general properties • Revere Oxygen-free Copper has properties similar to Electrolytic Copper. It has high electrical conductivity, is excellent for deep drawing, and resists embrittling gases at high temperatures.

typical uses • Especially suited for drawing and stamping. Also for sealing to glass such as lamp bulbs, electronic tubes and the like.

physical properties (strip)	hard ■	soft □
tensile strength, psi (000 omitted)	50	32
elongation, % in 2 in.	5	40
yield strength, 0.5% extension, psi (000 omitted)	48	8
Rockwell hardness	50B	40F
density, lb per cu in.	0.323	
average coefficient of thermal expansion, per °F (68 to 570°F)	0.000098	
electrical conductivity, % IACS, at 68°F	100 min	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F.	227	

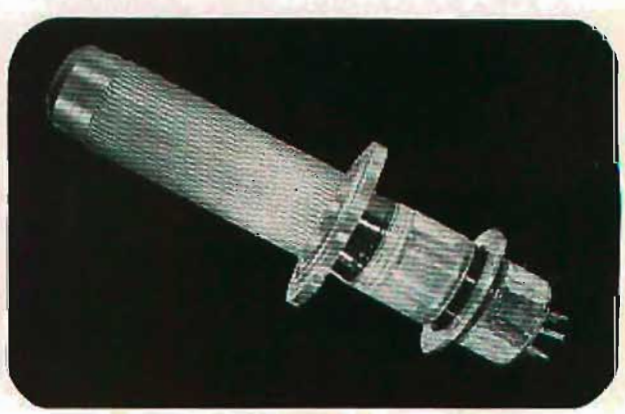
■ based on material previously rolled four B&S numbers hard (37.5% area reduction)

□ based on grain size of 0.035 mm.
All tests conducted on 0.040 in. stock.

working properties • Cold working, hot working, soldering, polishing—excellent. Machining—fair. Welding—see page 54.

ASTM specifications

sheet, strip: B101, B152
rod: B12, B133, B49, B187, B124
tube: B13, B111, B68, B188, B75



gree of softness of brass can most accurately be expressed in terms of actual average grain size measured on the surface of the metal at high magnification after it has been specially prepared to make the structure visible. At this magnification (usually 75 diameters) the diameter of the average individual grain is actually measured.

Annealed brass is furnished in grain sizes ranging from .010 to .150 mm. average diameter. The surface quality of a finished piece of drawn brass is directly affected by the initial grain size of the material. Brasses with smaller grain size (.015 to .035 mm.) are not so ductile as those with larger grain size—but are utilized for applications where cold-working is not too severe and where, after such cold-working, a high polish is desired. Such brasses possess excellent surfaces and require a minimum of polishing after cold-work to obtain high lustre.

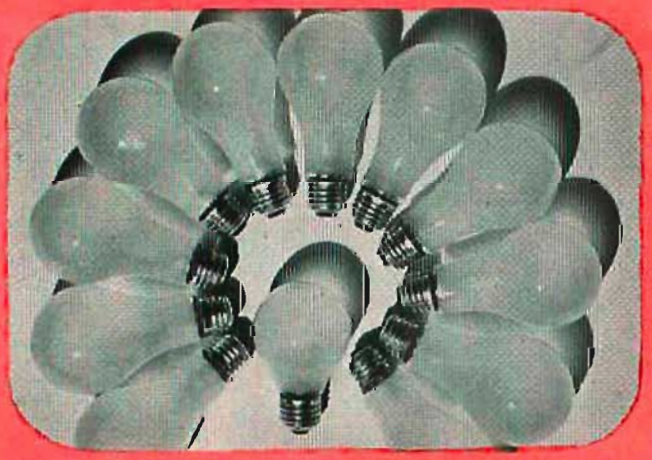
For heavier and more severe cold-working operations, brasses having grain sizes of .030 to .050 mm. are used. These permit more severe operations but require more care after working to produce a polished surface. Above grain size of .050 mm., even light working produces a roughened surface; as the grain size increases to .100 mm. it becomes increasingly difficult to finish the surface satisfactorily. Most deep drawing brass is furnished with a grain size of .035 to .050 mm.

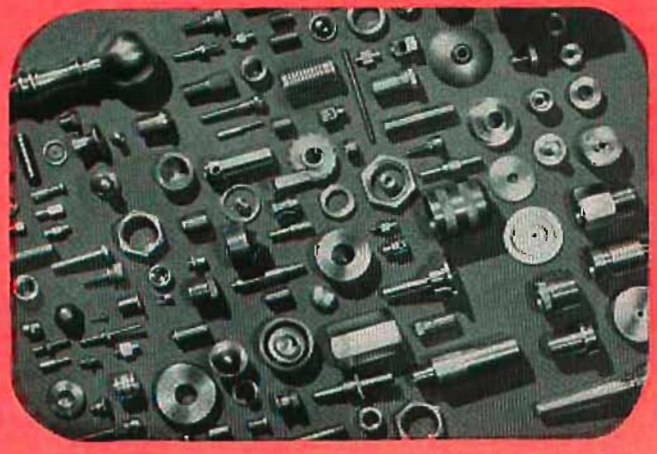
commonly used grain sizes

mm	recommended for
.015	slight forming operation
.025	drawing work such as hub caps
.035	good drawing and polishing as for headlight reflectors
.050	heavy drawing and spinning; is more difficult to polish
.100	severe draws on heavy material

brass

alloy name	Commercial Bronze 95% *(Gilding)*	
Revere alloy number	110	
composition: copper	95.0	
composition: zinc	5.0	
composition: lead	..	
composition: nickel	..	
composition: tin	..	
typical uses	jewelry, emblems, plaques, coins, fuse caps, primers as base for articles to be gold plated or highly polished	
general properties	compared to copper, this alloy has higher tensile strength, equal ductility, lower thermal properties golden color	
working properties: cold-working	excellent	
working properties: hot-working	excellent	
working properties: machining	poor	
working properties: welding	gas, carbon arc, metal arc	
working properties: soldering	excellent	
working properties: polishing	excellent	
density, lb per cu in	0.320	
Young's modulus of elasticity, psi (000,000 omitted)	15	
melting point, °F	1949	
average coefficient of thermal expansion, per °F (68 to 570°F)	.0000100	
electrical conductivity, % IACS at 68°F	57.0	
thermal conductivity—Btu per sq ft, per ft, per hr, per °F, at 68°F	139	
	hard	*soft*
tensile strength, psi (000 omitted): sheet ■	58	37
tensile strength, psi (000 omitted): rod □	..	..
tensile strength, psi (000 omitted): tube	..	..
elongation, % in 2 in.: sheet ■	5	45
elongation, % in 2 in.: rod □	..	..
elongation, % in 2 in.: tube	..	..
yield strength 0.5% extension under load, psi (000 omitted): sheet ■	52	8
yield strength 0.5% extension under load, psi (000 omitted): rod □	..	..
yield strength 0.5% extension under load, psi (000 omitted): tube	..	..
Rockwell hardness: sheet ■	60B	50F
Rockwell hardness: rod □	..	..
Rockwell hardness: tube	..	..
ASTM specifications: sheet, strip	B36	
ASTM specifications: rod	B134	
ASTM specifications: tube	..	
for further data, see	. . . .	





the number of Brown & Sharpe gauges which the metal is to be reduced by cold rolling, without any intermediate annealing. The amount of cold-working obtained by these reductions is also quite generally referred to as ¼ hard, ½ hard, etc., as stated in the table below:

rolled sheet and strip

temper	nominal reduction B&S gauge no.	percentage of reduction (approx.)
¼ hard	1	10.9
½ hard	2	20.7
hard	4	37.1
extra hard	6	50.0
spring	8	60.5
extra spring	10	68.7

It is seen that a reduction in gauge of 2 B&S numbers produces a temper known as ½ hard. This also designates a definite reduction in the thickness of the metal. Spring temper, for example, corresponds to a reduction in gauge of 8 Brown & Sharpe gauge numbers and a reduction in thickness of 60.5%.

The actual resulting hardness depends not only on the reduction or amount of cold-working to which the metal has been subjected, but also on the initial grain size and the composition or mixtures of the alloy. Therefore "numbers hard" or phrases such as ¼ hard, ½ hard, etc., are only approximate designations of true physical properties.

annealing

If copper or brass is cold-worked—to increase the hardness—the only method by which it can be softened is by annealing. This may be done by heating to between 600° and 1200°F. The precise temperature range depends upon the alloy and the amount the metal has been cold-worked prior to the annealing operation and the finished hardness desired. Low annealing temperatures soften the metal least; high annealing temperatures soften it most.

Grain size is an important indication of the temper and working properties. During annealing the grains increase in size as described below.

grain size

All metals are crystalline and in mill terminology the crystals are referred to as "grains". The grain size is important in specifications as it has a definite effect in forming and subsequent operations. The de-

leaded brass

alloy name	Leaded Brass		Engravers or Heavy Leaded Brass		Free-cutting Rod		Forging Rod		Architectural Bronze	
Revere alloy number	224		235		240		280		283	
composition: copper	66.5		64.0		61.5		60.0		56.5	
composition: zinc	32.9		32.0		35.5		38.0		41.25	
composition: lead	0.6		2.0		3.0		2.0		2.25	
composition: nickel	..		..		..		..		..	
composition: tin	..		..		..		..		..	
typical uses	screw machine parts; electrical fuse parts; plumbing; pipe, pump liners		engraving plates; machined parts; instruments (professional and scientific); name plates, keys, lock parts, tumblers; gears; watch parts		deep drilling turning, free cutting for screw machine parts		hot forgings; hardware; plumbing goods		handrails, decorative moldings, grilles; revolving door parts; miscellaneous architectural trim; industrial extruded shapes (hinges, lock bodies, automotive parts)	
general properties	free machining combined with moderate cold-forming ability		free machining and good blanking		excellent machinability combined with good mechanical and corrosion resistance properties		extremely plastic hot, combining good corrosion resistance with excellent mechanical properties		excellent forging and free machining properties	
working properties: cold-working	fair		poor		poor		fair		very poor	
working properties: hot-working	poor		poor		good		excellent		excellent	
working properties: machining	good		excellent		excellent		good		good	
working properties: welding	non-leaded brass preferred		non-leaded brass preferred		non-leaded brass preferred		non-leaded brass preferred		poor	
working properties: soldering	excellent		excellent		good		good		excellent	
working properties: polishing	excellent		excellent		excellent		excellent		excellent	
density, lb per cu in.	0.307		0.306		0.307		0.305		0.305	
Young's modulus of elasticity, psi (000,000 omitted)	15		15		15		15		15	
melting point, °F	1715		1680		1652		1643		1623	
average coefficient of thermal expansion, per °F (68 to 570°F)	.0000113		.0000111		.0000113		.0000115		..	
electrical conductivity, % IACS at 68°F	26.8		26.8		28.6		28.6		..	
thermal conductivity, Btu. per sq ft, per ft, per hr, per °F, at 68°F	69		69		73		73		..	
	hard	*soft*	*hard*	*soft*	*hard*	*soft*	*hard*	*soft**	*hard*	*soft*
tensile strength psi (000 omitted): sheet ■	..	..	80	50	..	..	..	..	..	..
tensile strength psi (000 omitted): rod □	..	..	..	..	65	50	..	55	..	65
tensile strength psi (000 omitted): tube	75	50	..	..	..	..	..	..	..	..
elongation, % in 2 in.: sheet ■	..	..	5	55	..	..	..	..	..	..
elongation, % in 2 in.: rod □	..	..	..	..	15	50	..	45	..	15
elongation, % in 2 in.: tube	10	50	..	..	..	..	..	..	..	..
yield strength 0.5% extension under load psi (000 omitted): sheet ■	..	..	65	18	..	..	..	..	..	..
yield strength 0.5% extension under load psi (000 omitted): rod □	..	..	..	..	..	15	..	20	..	35
yield strength 0.5% extension under load psi (000 omitted): tube	52	15	..	..	..	..	..	..	..	..
Rockwell hardness: sheet ■	..	..	80B	65F	..	..	..	..	..	..
Rockwell hardness: rod □	..	..	..	..	72B	65F	..	40B	..	85B
Rockwell hardness: tube	78B	20B	..	..	..	..	..	..	..	..
ASTM specifications: sheet, strip	..		..		B16		B124		..	
ASTM specifications: rod	..		..		..		..		..	
ASTM specifications: tube	B135		..						..	
for further data see	. . . .		. . . .		*page 24*		. . . .		. . . .	

■ *hard*, based on sheet and strip previously rolled 4 B & S numbers hard (37.5% area reduction); *soft*, based on soft sheet and strip with grain size of 0.035 mm. All tests conducted on 0.040-inch stock.

□ *hard*, based on rod with final reduction of 25%; *soft*, based on final grain size of 0.035 mm. All tests conducted on rod under 1 inch in diameter.

* properties given are for extruded condition only.

Commercial Bronze 90%	**Red-Brass 85%** *(Rich Low Brass)*	**Red-Brass 80%**	**Seventy-Thirty** *(Cartridge Brass)*	**Yellow Brass**	**Muntz Metal** *(Yellow Metal)*
120	130	140	160	170	180
90.0 10.0	85.0 15.0	80.0 20.0	70.0 30.0	66.0 34.0	60.0 40.0 .. .. ..
costume jewelry, compacts, lipstick cases forgings, screws, weatherstripping, stamped hardware	jewelry, badges, name plates, tags, dials, hardware, etched parts automobile radiators tube and pipe for oil and utility fields and plumbing	jewelry, thermostat bellows, deep drawn articles	for cartridge cases and ammunition components	for deep drawing, stamping, spinning, etching, rolling—for practically all fabricating processes pins, rivets, eyelets, auto radiator cores, heating units, lamp bodies and reflectors, cartridge cases and clips, electrical sockets, drawn shapes, etc.	sheet form for ship sheathing, condenser heads, perforated metal, architectural work condenser tubes valve stems, brazing rods
excellent cold-working properties very ductile	higher strength and ductility than copper excellent corrosion resistance often exceeding that of copper more successful at high temperature than higher zinc alloys	similar to 85% Red-Brass	best combination of ductility and strength of any brass excellent cold-working properties	excellent cold-working properties combined with good corrosion resistance mechanical properties and corrosion resistance almost the same as Deep Drawing and Cartridge Brass	high strength combined with low ductility
excellent excellent poor gas, carbon arc, metal arc excellent excellent	excellent good poor △ excellent excellent	excellent good poor △ excellent excellent	excellent good fair △ excellent excellent	excellent poor fair △ excellent excellent	fair excellent good △ excellent excellent
0.318	0.316	0.313	0.308	0.306	0.303
15	15	15	15	15	15
1913	1870	1832	1751	1700	1661
.0000101	.0000104	.0000106	.0000111	.0000114	.0000116
43.6	34.7	32	27.3	27.0	28.6
108	87	81	70	67	73

hard	*soft*	*hard*	*soft*	*hard*	*soft*	*hard*	*soft*	*hard*	*soft*	*hard*	*soft*
60 60 ..	38 38 ..	65 57 82	40 40 40	75 65 89	43 43 43	84 75 90	49 50 49	80 60 ..	48 50 ..	85 75 90	52 55 52
5 20 ..	40 55 ..	5 23 5	45 55 40	5 20 5	50 60 45	5 25 5	55 60 65	7 25 ..	60 65 ..	5 20 5	50 50 45
52 55 ..	10 10 ..	55 52 50	10 10 10	60 55 55	12 12 12	65 55 65	15 18 15	60 45 ..	15 18 ..	60 55 60	17 17 17
70B 60B ..	50F 50F ..	75B 75B 80B	53F 55F 55F	85B 75B 85B	60F 65F 60F	85B 82B 90B	30B 25B 30B	85B 70B ..	70F 20B ..	85B 80B 88B	30B 38B 30B
B36 B130 ..		B36 B134 B43		B36		B19 B134 B135		B36 B134 ..		B43 B111, B135	
page 16		*page 18*		. . . .		*page 20*		page 22		page 22	

■ *hard*, based on sheet and strip previously rolled 4 B & S numbers hard (37.5% area reduction); *soft*, based on soft sheet and strip with grain size of 0.035 mm. All tests conducted on 0.040-inch stock.

□ *hard*, based on rod with final reduction of 25%; *soft*, based on final grain size of 0.035 mm. All tests conducted on rod under 1 inch in diameter.

△ for welding—gas, carbon arc, metal arc, spot and seam welding for thin gauge.

tin brass

Chain Bronze	Admiralty Metal	Roman Bronze ▲	Naval Brass	Free-cutting Naval Brass	Manganese Bronze
340	358	380	386	389	454
87.0 11.75 .. 1.25	71.0 28.0 As 0.05 1.0	60.0 39.25 .. 0.75	60.0 39.0 0.25 .. 0.75	60.0 37.25 1.75 .. 0.75	58.0 39.6 Fe 1.4 Mn 0.5 Max. 1.0
sash chain and other similar chains	condenser and heat exchanger plates and tubes steam power plant equipment chemical and process equipment marine uses automobile aerials	propeller and pump shafts, piston rods many marine uses	tube sheets in heat exchangers and steam condensers hot-worked forgings	screw machine products marine hardware forgings bolts	forgings condenser plates valve stems coal screens
strength and ductility combined	excellent corrosion resistance combined with strength and ductility	manufacturing process gives fine, uniform grain-structure high resistance to fatigue and salt water corrosion	resistance to salt water corrosion satisfactory for moderate cold-working operations	similar to Free-cutting Rod (240) but with increased strength and corrosion resistance	high strength combined with excellent wear resistance
good fair poor .. excellent excellent	good poor fair gas, carbon arc good good	fair excellent good △ excellent excellent	fair excellent good △ excellent excellent	poor good excellent non-leaded brass preferred good excellent	poor excellent good △ excellent excellent
0.317	0.308	0.304	0.304	0.305	0.302
15	15	15	15	15	15
1886	1715	1640	1640	1640	1630
.0000104	.0000112	.0000119	.0000119	.0000119	.0000118
30.2	24.7	26.1	25.8	25.8	23.6
81	64	70	68	68	59

hard	soft	hard	soft	hard	soft	hard	soft	hard	soft	hard	soft	hard	soft
67	45	95 .. 100	50 .. 50	.. 82 ..	.. 60 ..	90 80 ..	58 58 ..	90	58	.. 90 ..	.. 68 ..	 85	 50
5	45	5 .. 3	55 .. 58	.. 20 ..	.. 45 ..	5 20 ..	40 45 ..	5	35	.. 10 ..	.. 35 ..	 10	 50
60	12	70 .. 80	18 .. 15	.. 55 ..	.. 22 ..	70 55 ..	20 20 ..	70	20	.. 55 ..	.. 27 ..	 60	 20
60B	60F	90B .. 95B	25B .. 50F	.. 80B ..	.. 50B ..	90B 80B ..	45B 50B ..	90B	45B	.. 85B ..	.. 65B ..	.. .. 86B	.. .. 70F
..		B171 B111		..		B171 B21, B124 ..		..		B124, B133 ..		..	
. . . .		page 26		page 28		page 26		. . . .		page 28		. . . .	

special brass

Aluminum Brass (Revalon)
435
76.0 22.0 Al 2.25 As 0.05 ..
condenser and heat exchanger tubes steam power plant equipment chemical and process equipment marine uses
excellent corrosion resistance combined with good strength and ductility better than Admiralty (358) for resistance to velocity type of failure
good fair poor .. excellent ..
0.301
15
1770
.0000108
22.6
58

hard	soft
.. .. 85	 50
.. .. 10	 50
.. .. 60	 20
.. .. 86B	.. .. 70F
.. B111	
. . . .	

▲ similar to Naval Brass but more suitable to shafting—due to materially higher fatigue endurance limit.
△ for welding—gas, carbon arc, metal arc, spot and seam welding for thin gauge.

Commercial Bronze, 90%

also known as government gilding metal

alloy no. 120

copper 90.0% *zinc 10.0%*

forms available: sheet, strip, plate, rod, tube, forgings

general properties • Revere Commercial Bronze, 90%, has high ductility. Compared to copper, it has higher tensile strength but lower thermal properties.

typical uses • Commercial Bronze, 90%, is used for costume jewelry, compacts and lipstick cases. Also recommended for forgings, screws, weather stripping and standard hardware.

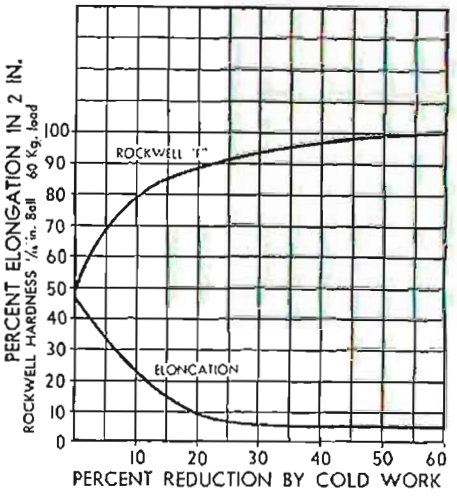
physical properties (sheet and strip)	hard ■	soft □
tensile strength, psi (000 omitted)	60	38
elongation, % in 2 in.	5	40
yield strength, 0.5% extension psi (000 omitted)	52	10
Rockwell hardness	70B	50F
density, lb per cu in.	0.318	
average coefficient of thermal expansion, per °F, (68 to 570°F)	0.0000101	
electrical conductivity, % IACS, at 68°F	43.6	
thermal conductivity, Btu per sq ft, per ft, per hr, per per °F, at 68°F	108	

■ based on material previously rolled four B&S numbers hard (37.5% area reduction)
□ based on grain size of 0.035 mm.
All tests conducted on 0.040 in. stock.

working properties • Cold working, soldering, polishing—excellent. Hot working—excellent if lead free. Machining—poor. Welding—see page 56.

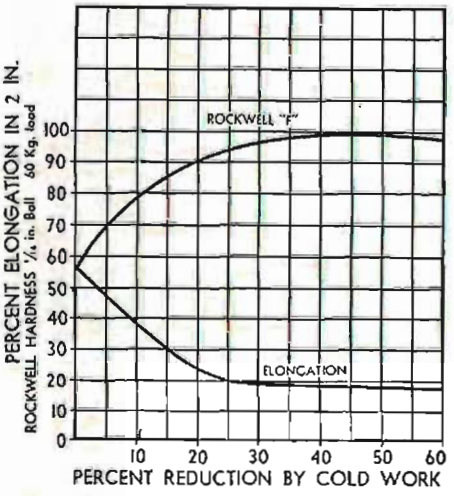
ASTM specifications • Sheet: B36, B130.

sheet cold working



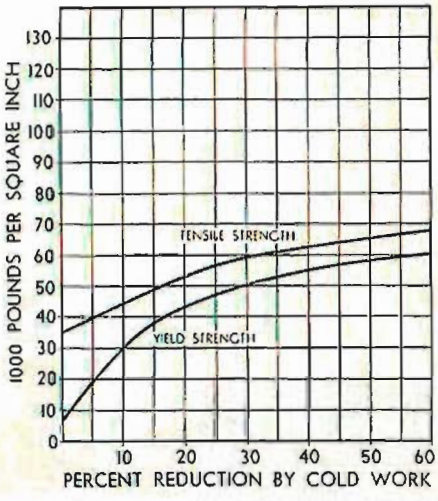
Rockwell F hardness, elongation of Commercial Bronze strip previously annealed to a grain size of 0.070 mm.

rod cold working

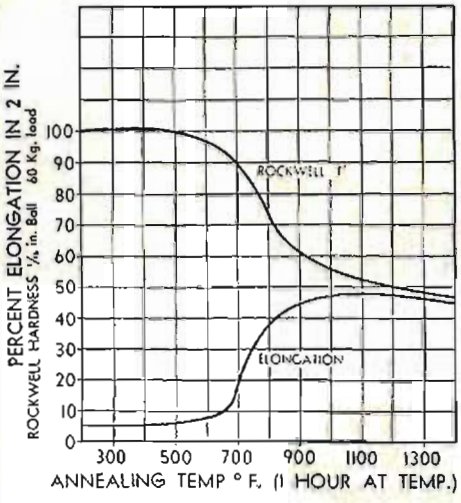


Rockwell F hardness, elongation of Commercial Bronze rod previously annealed to a grain size of 0.050 mm.

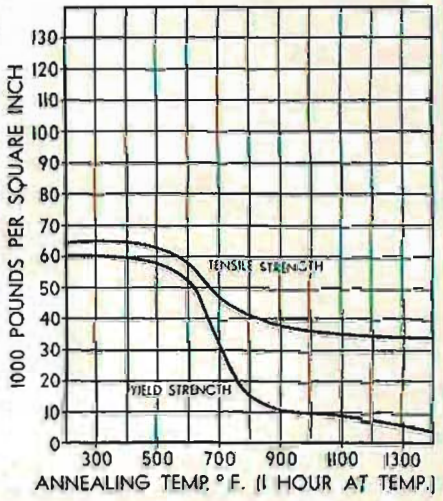
annealing



tensile strength, yield strength (0.5%) of Commercial Bronze strip previously annealed to a grain size of 0.070 mm.

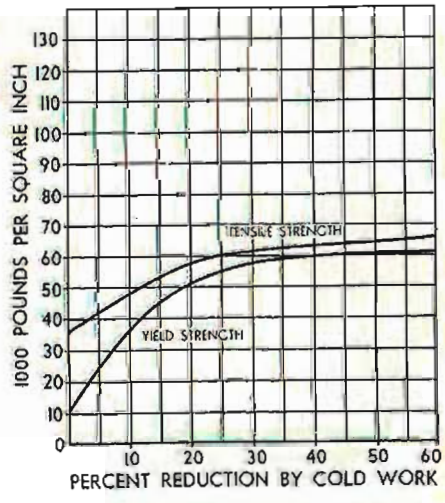


Rockwell F hardness, elongation of Commercial Bronze strip previously cold rolled 50% from material having a grain size of 0.070 mm.

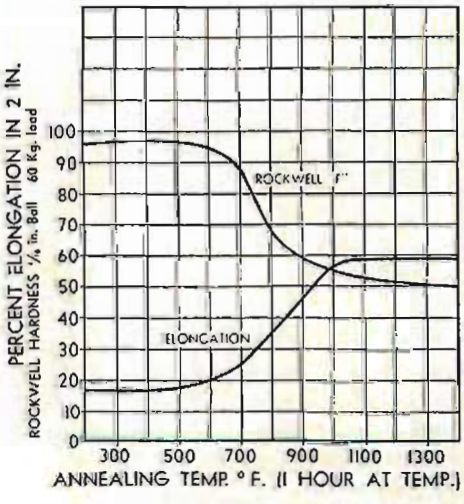


tensile strength, yield strength (0.5%) of Commercial Bronze strip previously cold rolled 50% from material having a grain size of 0.070 mm.

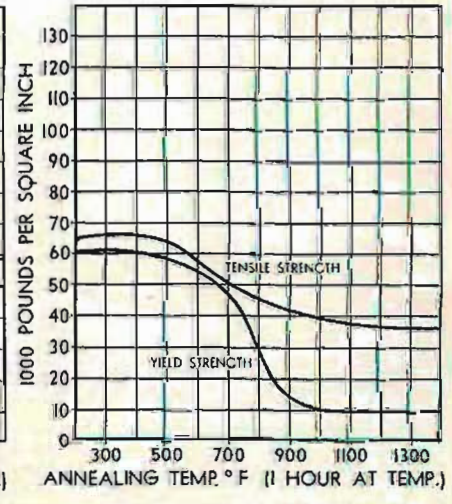
annealing



tensile strength, yield strength (0.5%) of Commercial Bronze rod previously annealed to a grain size of 0.050 mm.



Rockwell F hardness, elongation of Commercial Bronze rod previously cold worked 37% from material having a grain size of 0.050 mm.



tensile strength, yield strength of Commercial Bronze rod previously cold worked 37% from material having a grain size of 0.050 mm.

→ the charts at small scale on these pages are intended to indicate range of properties and not to present exact data.

Red-Brass, 85%

also known as Rich Low Brass

alloy no. 130

copper *85.0%* zinc *15.0%*

forms available: sheet, strip, plate, rod, wire, tube, pipe and lockseam tubing

general properties • Revere Red-Brass, 85%, has higher strength and greater ductility than copper, and its excellent corrosion resistance often exceeds that of copper, as in salt water.

typical uses • Red-Brass, 85%, is recommended for jewelry, name plates, badges, tags, dials, hardware, etched parts. For tubing and pipe for oil and utility fields and plumbing. Also for automobile radiators, bellows and flexible tubing.

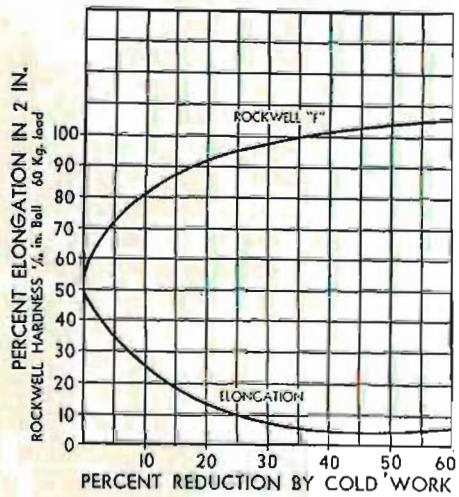
physical properties (sheet and strip)	hard ■	soft □
tensile strength, psi (000 omitted)	65	40
elongation, % in 2 in.	5	45
yield strength, 0.5% extension, psi (000 omitted)	55	10
Rockwell hardness	75B	60F
density, lb per cu in.	0.316	
average coefficient of thermal expansion per °F, (68 to 570°F)	0.0000104	
electrical conductivity, % IACS, at 68°F	34.7	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	87	

■ based on material previously rolled four B&S numbers hard (37.5% area reduction)
□ based on grain size of 0.035 mm.
all tests conducted on 0.040 in. stock.

working properties • Cold working, soldering, polishing—excellent. Hot working—good if lead free. Machining—fair. Welding—see page 56.

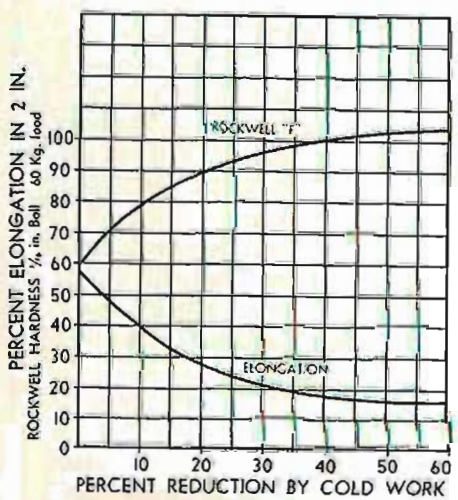
ASTM specifications • Sheet: B36. Tube: B43.

sheet cold working



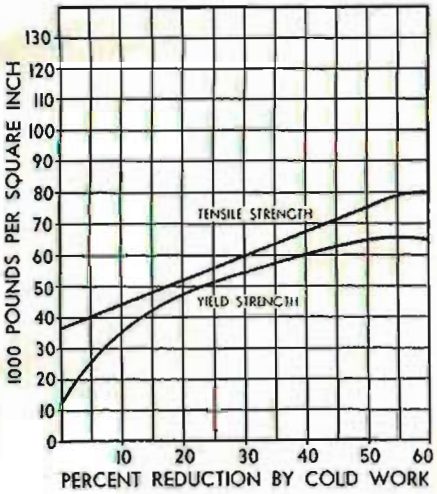
Rockwell F hardness, elongation of Red-Brass strip previously annealed to a grain size of 0.070 mm.

rod cold working

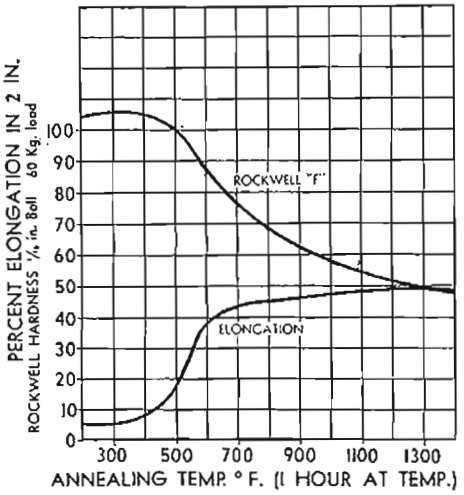


Rockwell F hardness, elongation of Red-Brass rod previously annealed to a grain size of 0.055 mm.

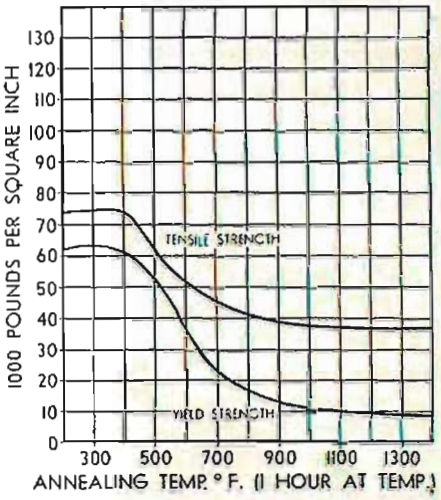
annealing



tensile strength, yield strength (0.5%) of Red-Brass strip previously annealed to a grain size of 0.070 mm.

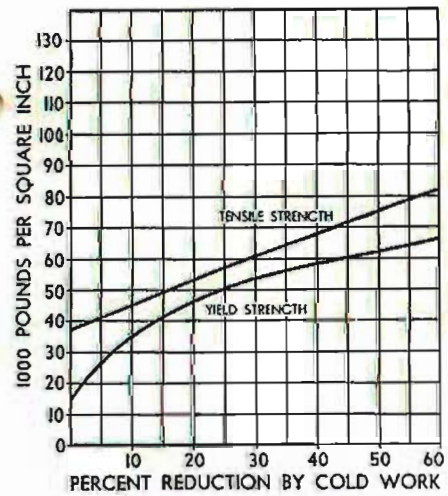


Rockwell F hardness, elongation of Red-Brass strip previously cold rolled 50% from material having a grain size of 0.070 mm.

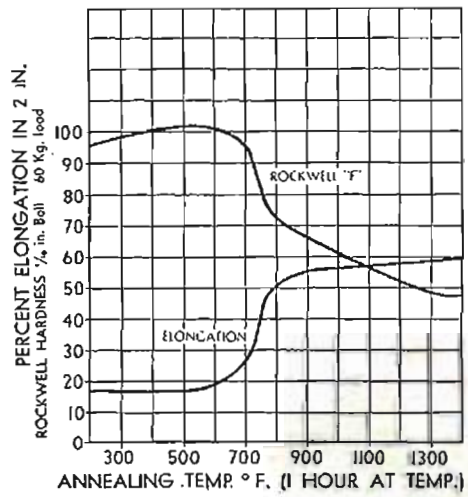


tensile strength, yield strength (0.5%) of Red-Brass strip previously cold rolled 50% from material having a grain size of 0.070 mm.

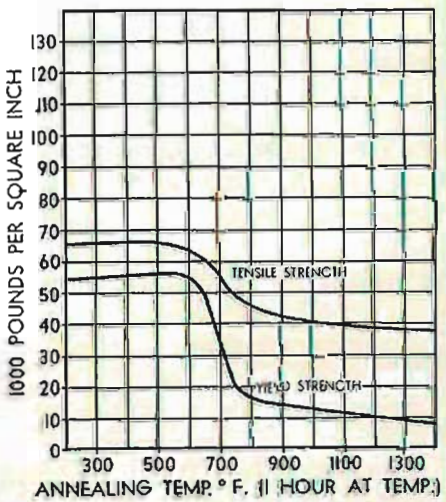
annealing



tensile strength, yield strength (0.5%) of Red-Brass rod previously annealed to a grain size of 0.055 mm.



Rockwell F hardness, elongation of Red-Brass rod previously cold worked 37% from material having a grain size of 0.055 mm.



tensile strength, yield strength (0.5%) of Red-Brass rod previously cold worked 37% from material having a grain size of 0.055 mm.

→ **the charts at small scale on these pages are intended to indicate range of properties and not to present exact data**

Seventy-Thirty Brass

also known as Cartridge Brass

alloy no. 160

copper 70.0% *zinc 30.0%*

forms available: sheet, strip, tube, rod, rectangular bar and lockseam tubing

general properties • Revere Seventy-Thirty Brass has the best combination of ductility and strength of all the brasses and accordingly has superior cold working properties.

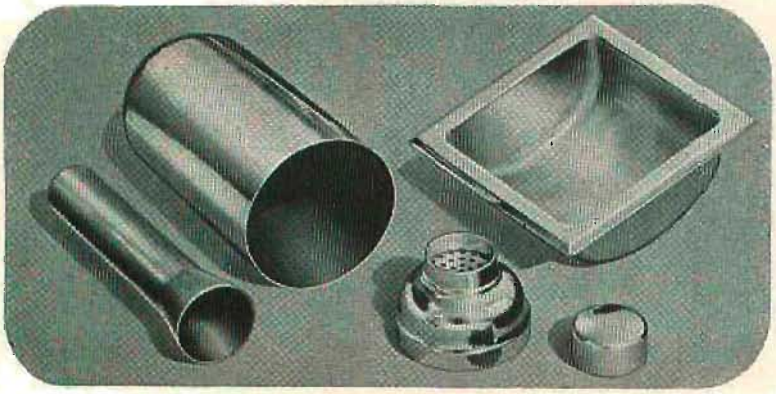
typical uses • Seventy-Thirty Brass is recommended for cartridge cases, ammunition components and for any difficult deep drawing, stamping or spinning job.

physical properties (sheet and strip)	hard ■	soft □
tensile strength, psi (000 omitted)	84	49
elongation, % in 2 in.	5	55
yield strength, 0.5% extension psi (000 omitted)	65	15
Rockwell hardness	85B	30B
density, lb per cu in.	0.308	
average coefficient of thermal expansion per °F, (68 to 570°F)	0.0000111	
electrical conductivity, % IACS, at 68°F	27.3	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	70	

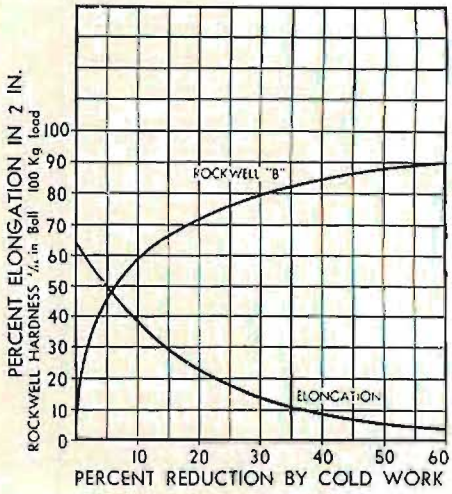
■ based on material previously rolled four B&S numbers hard (37.5% area reduction)
□ based on grain size of 0.035 mm.
all tests conducted on 0.040 in. stock.

working properties • Cold working, soldering, polishing—excellent. Hot working—good if lead free. Machining—fair. Welding—see page 56.

ASTM specifications • Sheet: B19. Tube: B 135. Rod: B134.

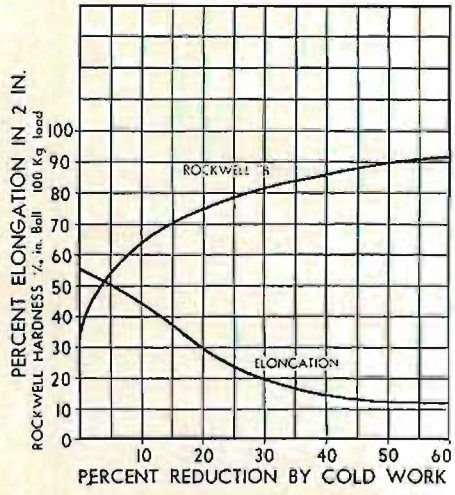


sheet cold working



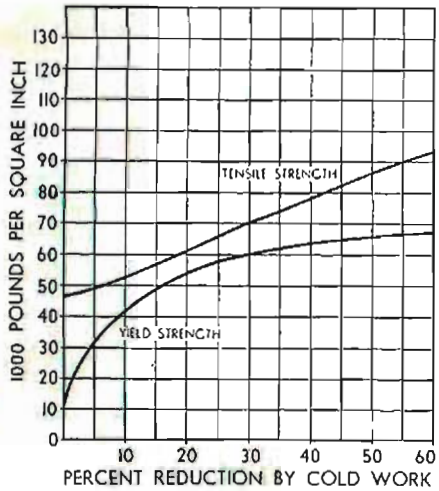
Rockwell B hardness, elongation of 70-30 Brass strip previously annealed to a grain size of 0.070 mm.

rod cold working

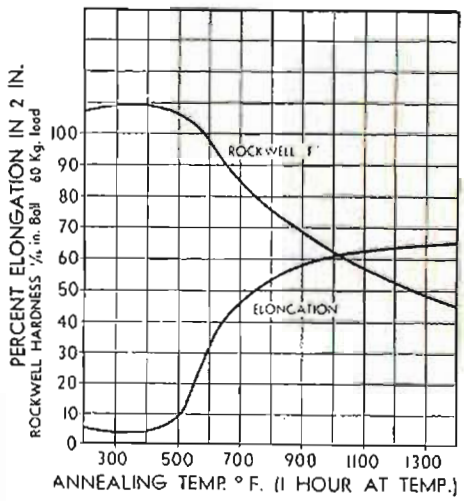


Rockwell B hardness, elongation of 70-30 Brass rod previously annealed to a grain size of 0.045 mm.

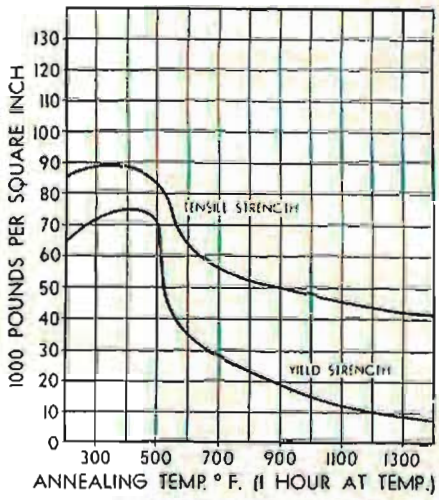
annealing



tensile strength, yield strength (0.5%) of 70-30 Brass strip previously annealed to a grain size of 0.070 mm.

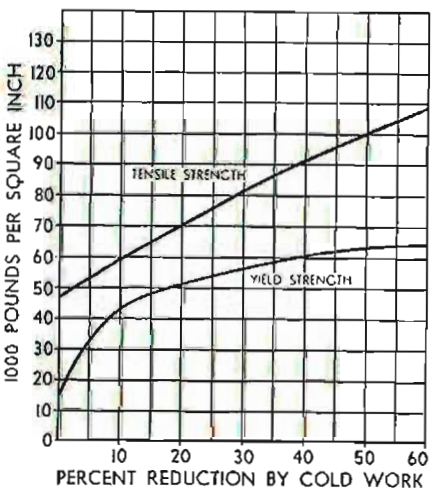


Rockwell F hardness, elongation of 70-30 Brass strip previously cold rolled 50% from material having a grain size of 0.070 mm.

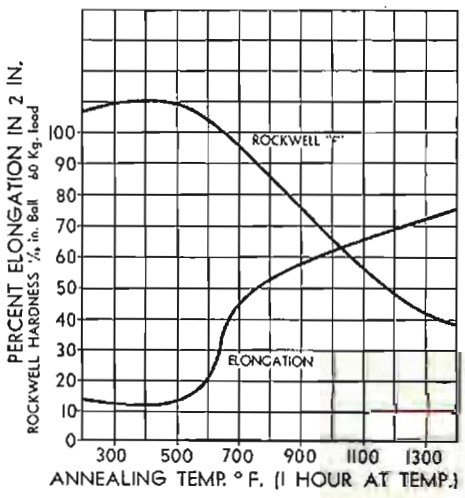


tensile strength, yield strength (0.5%) of 70-30 Brass strip previously cold rolled 50% from material having a grain size of 0.070 mm.

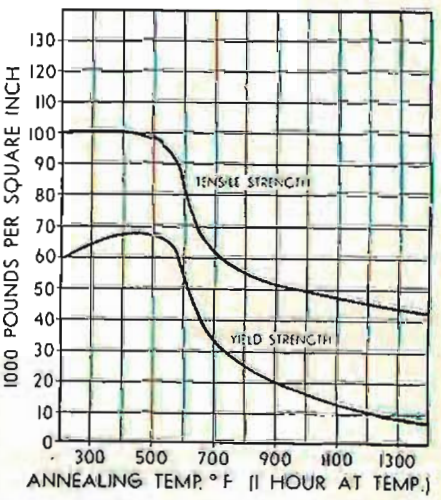
annealing



tensile strength, yield strength (0.5%) of 70-30 Brass rod previously annealed to a grain size of 0.045 mm.



Rockwell F hardness, elongation of 70-30 Brass rod previously cold worked 50% from material having a grain size of 0.045 mm.



tensile strength, yield strength (0.5%) of 70-30 Brass rod previously cold worked 50% from material having a grain size of 0.045 mm.

→ the charts at small scale on these pages are intended to indicate range of properties and not to present exact data.

Yellow Brass

alloy no. 170

copper 66.0% *zinc 34.0%*

available in sheet, strip, rod, wire, and lockseam tubing

general properties ● Revere Yellow Brass possesses excellent cold-working properties with good corrosion resistance. Mechanical properties and corrosion resistance are similar to those of alloys no. 160 and no. 165.

typical uses ● Yellow Brass is recommended for pins, rivets, eyelets, auto radiator cores, heating units, lamp bodies and reflectors, electrical sockets, and drawn shapes. Also for deep drawing, stamping, spinning, etching and rolling for practically all fabricating processes.

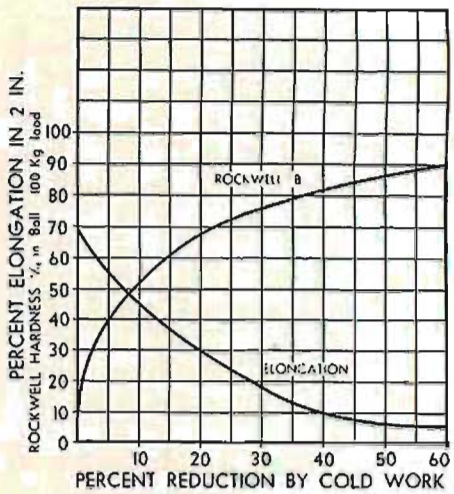
physical properties (sheet, strip)	hard ■	soft □
tensile strength, psi (000 omitted)	80	48
elongation, % in 2 in.	7	60
yield strength, 0.5% extension, psi (000 omitted)	60	15
Rockwell hardness	85B	70F
density, lb per cu in.	0.306	
average coefficient of thermal expansion, per °F (68 to 570°F)	0.0000114	
electrical conductivity, % IACS, at 68°F	26.4	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	69	

■ based on material previously rolled four B&S numbers hard (37.5% area reduction)
□ based on grain size of 0.035 mm.
all tests conducted on 0.040 in. stock.

working properties ● Cold working, soldering, polishing—excellent. Machining—fair. Welding—see page 56.

ASTM specifications ● Sheet: B36. Rod: B134.

sheet cold working



Rockwell B hardness, elongation of Yellow Brass strip previously annealed to a grain size of 0.070 mm.

Muntz Metal

also known as Yellow Metal

alloy no. 180

copper 60.0% *zinc 40.0%*

forms available: sheet, rod, tube, forgings, extruded shapes

general properties ● Revere Muntz Metal possesses high strength and low ductility. It has reasonably good resistance to corrosion.

typical uses ● Muntz Metal is recommended for ship sheathing, condenser tubes and sheets, perforated metal, architectural work, valve stems and brazing rods.

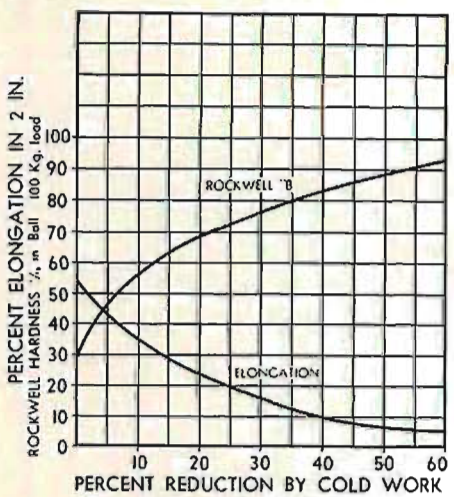
physical properties (sheet, strip)	hard ■	soft □
tensile strength, psi (000 omitted)	85	52
elongation, % in 2 in.	5	50
yield strength, 0.5% extension, psi (000 omitted)	60	17
Rockwell hardness	85B	30B
density, lb per cu in.	0.303	
average coefficient of thermal expansion, per °F (68 to 570°F)	0.0000116	
electrical conductivity, % IACS, at 68°F	28.6	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	73	

■ based on material previously rolled four B&S numbers hard (37.5% area reduction)
□ based on grain size of 0.035 mm.
all tests conducted on 0.040 in. stock.

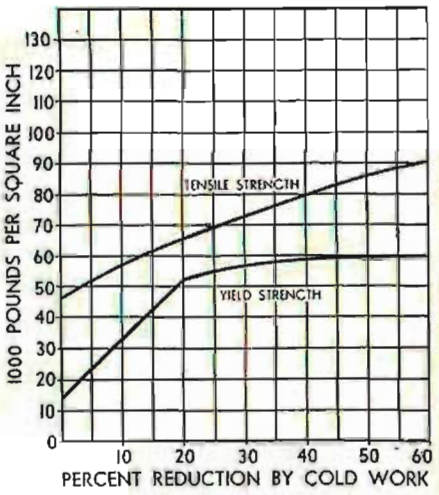
working properties ● Hot working, soldering, polishing—excellent. Cold working—fair. Machining—good. Welding—see page 56.

ASTM specifications ● Sheet: B43. Tube: B111, B135.

sheet cold working

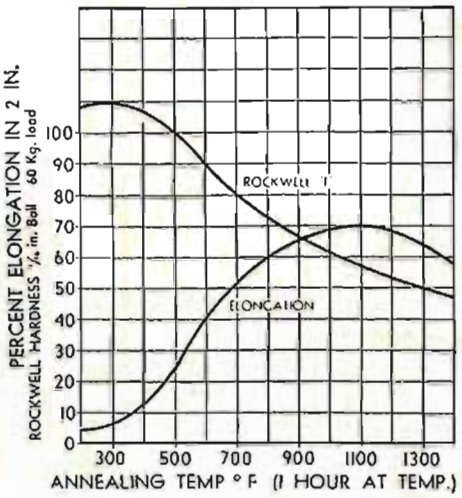


Rockwell B hardness, elongation of Muntz Metal strip previously annealed to a grain size of 0.045 mm.

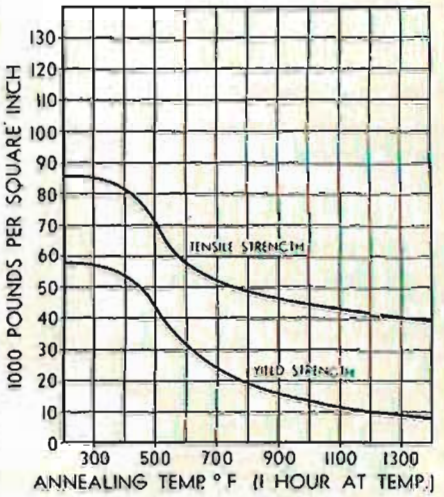


tensile strength, yield strength (0.5%) of Yellow Brass strip previously annealed to a grain size of 0.070 mm.

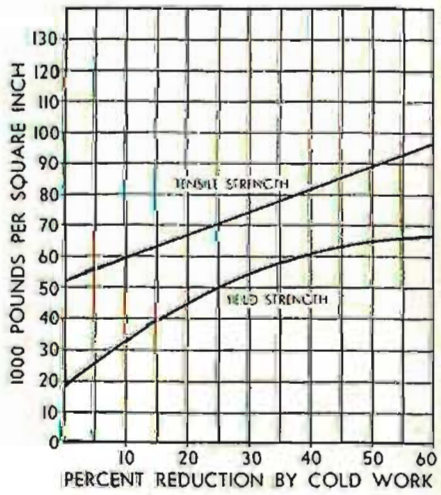
annealing



Rockwell F hardness, elongation of Yellow Brass strip previously cold rolled 50% from material having a grain size of 0.070 mm.

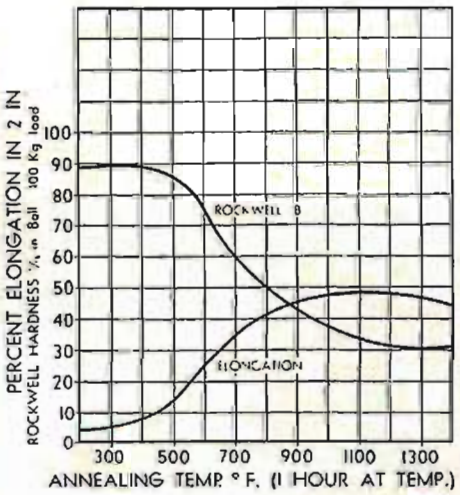


tensile strength, yield strength (0.5%) of Yellow Brass strip previously cold rolled 50% from material having a grain size of 0.070 mm.

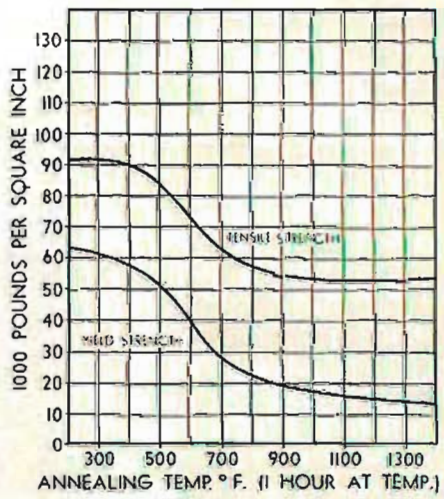


tensile strength, yield strength (0.5%) of Muntz Metal strip previously annealed to a grain size of 0.045 mm.

annealing



Rockwell B hardness, elongation of Muntz Metal strip previously cold rolled 50% from material having a grain size of 0.045 mm.



tensile strength, yield strength (0.5%) of Muntz Metal strip previously cold rolled 50% from material having a grain size of 0.045 mm.

→ the charts at small scale on these pages are intended to indicate range of properties and not to present exact data.

Free-cutting Rod

alloy no. 240

copper 61.5% *zinc 35.5%* *lead 3.0%*

forms available: rod, forgings, extruded shapes

general properties • Revere Free-cutting Rod combine machinability with good mechanical and corrosion resistance properties.

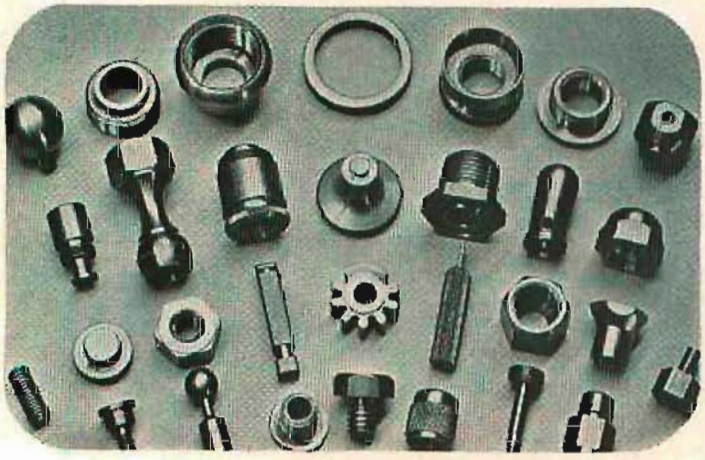
typical uses • Free-Cutting Rod is recommended for deep drilling, turning and free cutting for screw machine parts.

physical properties (rod)	hard ■	soft □
tensile strength, psi (000 omitted)	65	50
yield strength, 0.5% extension psi (000 omitted)	..	15
elongation, % in 2 in.	15	50
Rockwell hardness	72B	65F
density, lb per cu in.	0.307	
average coefficient of thermal expansion, per °F, (68 to 570 °F)	0.0000113	
electrical conductivity, % IACS, 68°F	28.6	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, @ 68° F	73	

■ based on final reduction of 25% (reduction area)
□ based on final grain size of 0.035 mm.
all tests conducted on rod under 1 in. in diameter

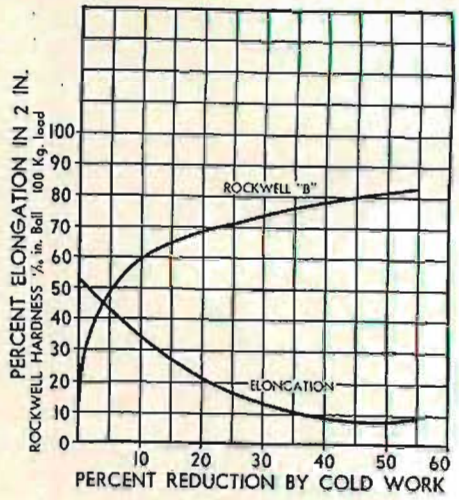
working properties • Cold working — poor. Hot working, soldering — good. Machining, polishing — excellent. Welding — see page 56.

ASTM specifications • Rod: B16.



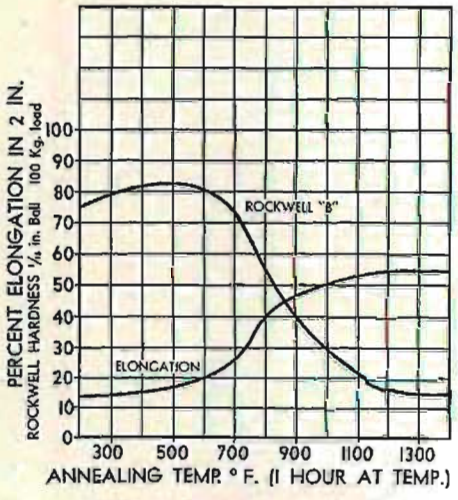
rod

cold working



Rockwell B hardness, elongation of Free-Cutting Brass rod previously annealed to a grain size of 0.025 mm.

annealing



Rockwell B hardness, elongation of Free-Cutting Brass rod previously cold worked 30% from material having a grain size of 0.025 mm.

other Revere Free-cutting Rod

Brass is a preferred material for screw machine parts. It is speedily machined; rust-proof, corrosion-resistant; finishes with smooth surface excellent for plating; its physical properties meet most needs; its scrap value is high. Brass, regardless of initial cost, is often the most economical material.

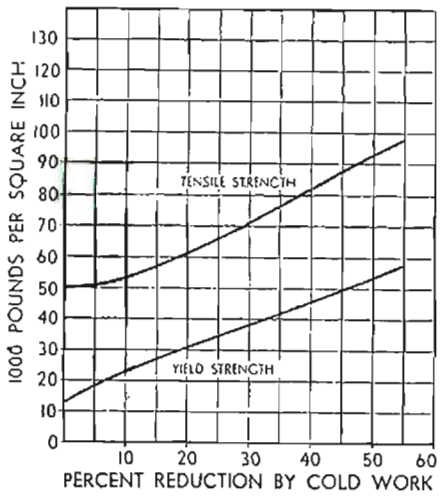
Obviously, the first requirement of free-cutting rod or free-turning rod is *machinability*. However, in selecting a leaded brass, thought must also be given to the influence of the lead on subsequent operations and on the service life of the fabricated part.

No single rod meets all requirements. Revere, therefore, fabricates a number of free-cutting rods in which the proper alloy and correct temper are combined to permit maximum machine speeds. Of these, alloy 240 (described at left) is most widely used in automatic screw machine work.

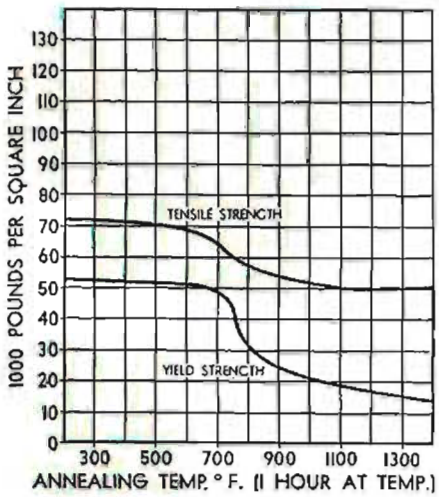
The table below giving the relative properties of Revere Free-cutting Rod alloys facilitates selection. When the proper alloy is doubtful, consult Revere for specific recommendations.

Alloys 250, 240, 247 and 252 are suitable for "automatic work." Their machinability increases and their cold-working properties decrease in order given. No. 250 is recommended when little machining but cold upsetting is required. No. 247, good all-around mixture, is suitable for peens, bends, riveting, etc. No. 240 is for high speed automatic machines. No. 227, highest in cost, for valve seats and parts requiring dense material.

Leaded Naval Brasses are variations of Roman Bronze and Naval Brass—depending on amounts of impurities. Recommended for applications where both strength and corrosion resistance are required. No. 388 is stronger and harder than No. 389, but wearing and machining properties are not as good.



tensile strength, yield strength (0.5%) of Free-Cutting Brass rod previously annealed to a grain size of 0.025 mm.



tensile strength, yield strength (0.5%) of Free-Cutting Brass rod previously cold worked 30% from material having a grain size of 0.025 mm.

the charts at small scale on these pages are intended to indicate range of properties and not to present exact data.

performance of Revere free-cutting rods

	alloy number	designation	performance		
			free machining	peening and upsetting	spinning
leaded brass	283	extruded shapes	good	fair	fair
	280	forging rod	satisfactory	satisfactory	satisfactory
	250	special low leaded brass	fair	good	good
	247	riveting and turning rod	satisfactory	satisfactory	satisfactory
	240	free cutting brass rod	good	fair—poor	fair—poor
	252	deep drilling rod	excellent	poor	poor
	227	leaded high brass (alpha)	satisfactory	good	good
leaded naval brasses	388	common naval brass	fair	fair	fair
	389	free cutting naval brass	satisfactory	poor	poor

Admiralty Metal

alloy no. 358

copper 71.0% zinc 28.0% arsenic 0.05% tin 1.0%

forms available: sheet, strip, plate, tube

general properties ● Excellent corrosion resistance, particularly in saline waters. Dezincification is inhibited by the arsenic addition. The combination of strength and ductility lends added value to this alloy.

typical uses ● Admiralty Metal is recommended for condenser and heat exchanger plates and tubes, steam power plant equipment, chemical and process equipment, marine uses and automobile aerials.

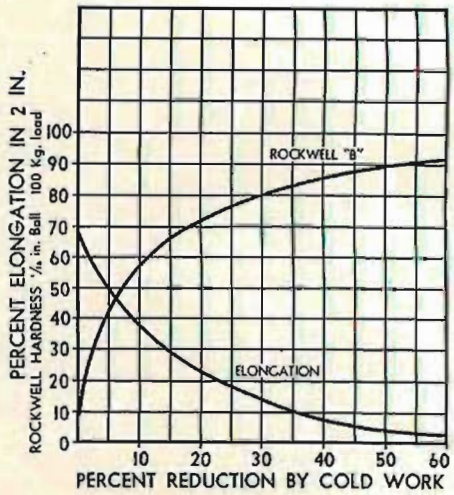
physical properties (sheet, strip)	hard ■	soft □
tensile strength, psi (000 omitted)	85	50
elongation, % in 2 in.	5	55
yield strength, 0.5% extension, psi (000 omitted)	70	18
Rockwell hardness	90B	25B
density, lb per cu in.	0.308	
average coefficient of thermal expansion, per °F (68 to 570°F)	0.0000112	
electrical conductivity, % IACS, at 68°F	24.7	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	64	

■ based on material previously rolled four B&S numbers hard (37.5% area reduction)
□ based on grain size of 0.035 mm. all tests conducted on 0.040 in. stock.

working properties ● Cold working—good. Hot working—poor. Machining—fair. Soldering, polishing—excellent. Welding—see page 56.

ASTM specifications ● Sheet: B171. Tube: B111.

sheet — cold working



Rockwell B hardness, elongation of Admiralty metal strip previously annealed to a grain size of 0.080 mm.

Naval Brass

alloy no. 386

copper 60.0% zinc 39.0% lead 0.25% max. tin 0.75%

forms available: sheet, strip, plate, rod, forgings, tube, extruded shapes

general properties ● Revere Naval Brass has good resistance to salt water corrosion. It will withstand moderate cold working.

typical uses ● Naval Brass is recommended for tube sheets in heat exchangers and steam condensers. Also for hot forgings.

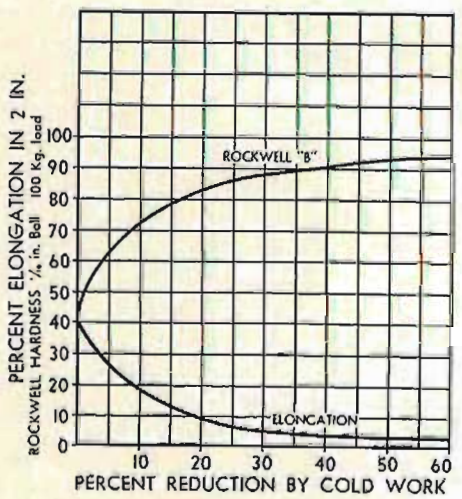
physical properties (sheet, strip)	hard ■	soft □
tensile strength, psi (000 omitted)	90	58
elongation, % in 2 in.	5	40
yield strength, 0.5% extension, psi (000 omitted)	70	20
Rockwell hardness	90B	45B
density, lb per cu in.	0.304	
average coefficient of thermal expansion, per °F (68 to 570°F)	0.0000119	
electrical conductivity, % IACS, at 68°F	25.8	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	68	

■ based on material previously rolled four B&S numbers hard (37.5% area reduction)
□ based on grain size of 0.035 mm. all tests conducted on 0.040 in. stock.

working properties ● Hot working, soldering, polishing—excellent. Cold working—fair. Machining—good. Welding—see page 56.

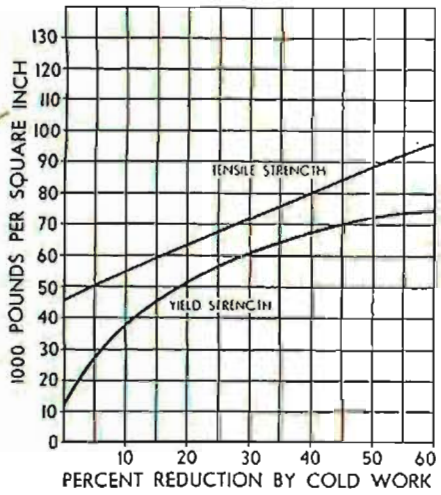
ASTM specifications ● Sheet: B171. Rod B21, B124.

sheet — cold working

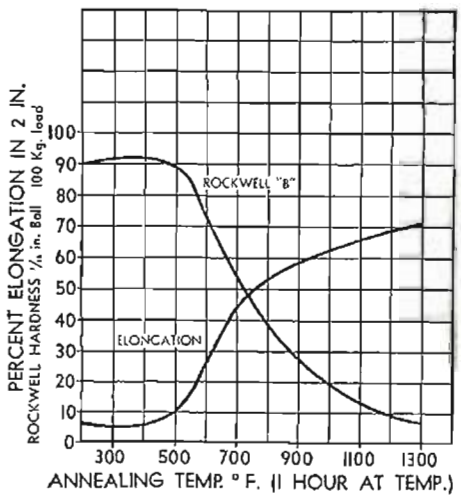


Rockwell B hardness, elongation of Government Naval Brass strip previously annealed to a grain size of 0.080 mm.

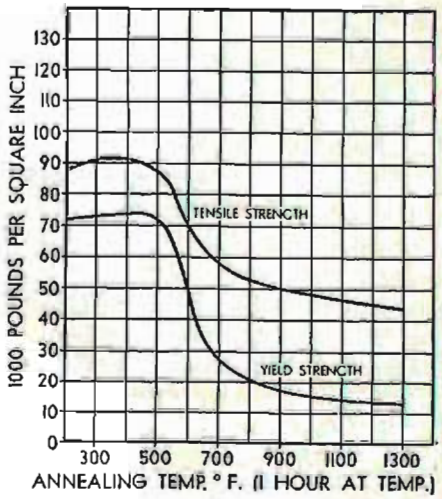
annealing



tensile strength, yield strength (0.5%) of Admiralty metal strip previously annealed to a grain size of 0.080 mm.

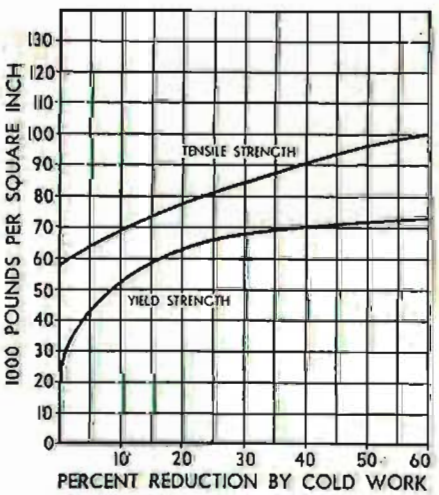


Rockwell B hardness, elongation of Admiralty metal strip previously cold rolled 50% from material having a grain size of 0.080 mm.

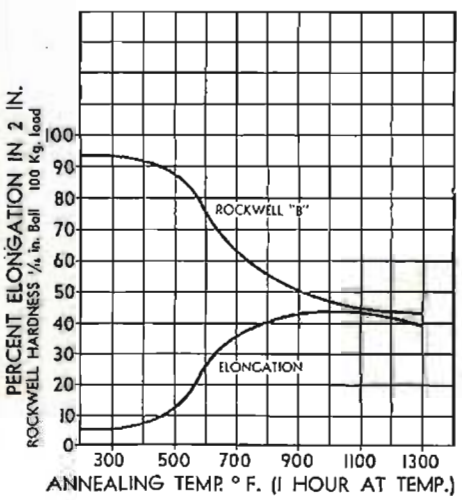


tensile strength, yield strength (0.5%) of Admiralty metal strip previously cold rolled 50% from material having a grain size of 0.080 mm.

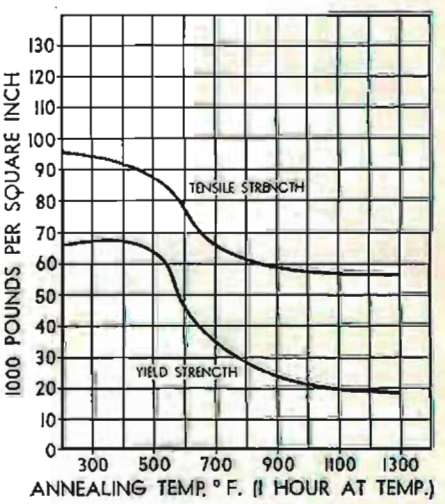
annealing



tensile strength, yield strength (0.5%) of Government Naval Brass strip previously annealed to a grain size of 0.080 mm.



Rockwell B hardness, elongation of Government Naval Brass strip previously cold rolled 50% from material having a grain size of 0.080 mm.



tensile strength, yield strength (0.5%) of Government Naval Brass strip previously cold rolled 50% from material having a grain size of 0.080 mm.

→ **the charts at small scale on these pages are intended to indicate range of properties and not to present exact data.**

Roman Bronze

alloy no. 380

copper 60.0% zinc 39.25% tin 0.75%

forms available: sheet, plate, rod, tube and forgings

general properties ● Revere Roman Bronze achieves a fine, uniform grain structure in manufacturing process. It is resistant to fatigue, salt water corrosion and corrosion fatigue. This alloy is similar to Naval Brass but is more suitable for shafting because of a materially higher endurance fatigue limit.

typical uses ● Roman Bronze is recommended for propeller and pump shafts, piston rods and many marine uses.

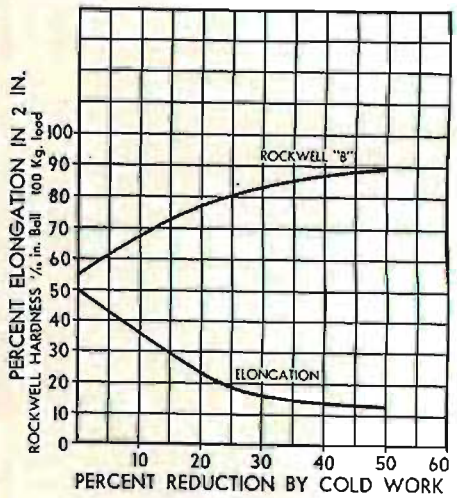
physical properties (rod)	hard ■	soft □
tensile strength, psi (000 omitted)	82	60
elongation, % in 2 in.	20	45
yield strength, 0.5% extension, psi (000 omitted)	55	22
Rockwell hardness	80B	50B
density, lb per cu in.	0.304	
average coefficient of thermal expansion, per °F (68 to 570°F)	0.0000119	
electrical conductivity, % IACS, at 68°F	26.1	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	70	

■ based on final reduction of 25% (reduction area)
□ based on final grain size of 0.035 mm.
all tests conducted on rod under 1 in. in diameter

working properties ● Cold working—fair. Hot working, soldering, polishing—excellent. Machining—good. Welding—see page 56.

ASTM specifications ● Rod: B21, B124.

rod cold working



Rockwell B hardness, elongation of Roman Bronze rod previously annealed to a grain size of 0.025 mm.

Manganese Bronze

alloy no. 454

copper 58.0% zinc 39.75% iron 0.75%
manganese 0.50% tin 1.0%

forms available: sheet, plate, rod, forgings, extruded shapes

general properties ● Revere Manganese Bronze has the highest mechanical properties of all the brasses together with good abrasion and corrosion resistance.

typical uses ● Pump rods, valve stems, dies, marine hardware, bolts, slotted or perforated screens.

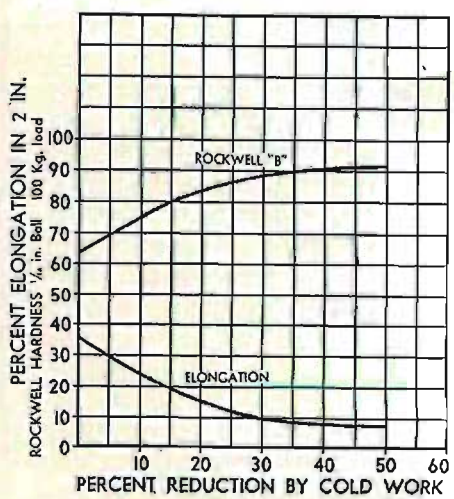
physical properties (rod)	hard ■	soft □
tensile strength, psi (000 omitted)	90	65
elongation, % in 2 in.	10	35
yield strength, 0.5% extension, psi (000 omitted)	55	27
Rockwell hardness	85B	65B
density, lb per cu in.	0.302	
average coefficient of thermal expansion, per °F (68 to 570°F)	0.0000118	
electrical conductivity, % IACS, at 68°F	23.6	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	58	

■ based on final reduction of 25% (reduction area)
□ based on final grain size of 0.035 mm.
all tests conducted on rod under 1 in. in diameter

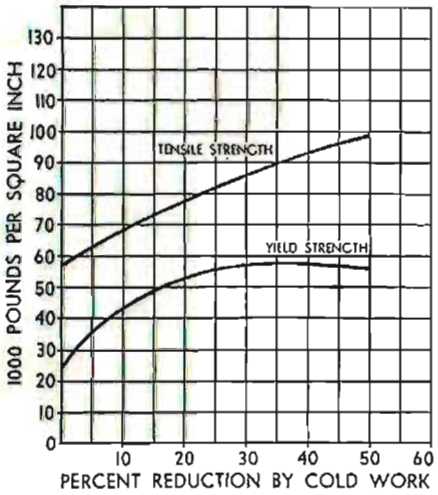
working properties ● Hot working, soldering, polishing—excellent. Cold working—poor. Machining—good. Welding—see page 56.

ASTM specifications ● Rod: B124, B138.

rod cold working

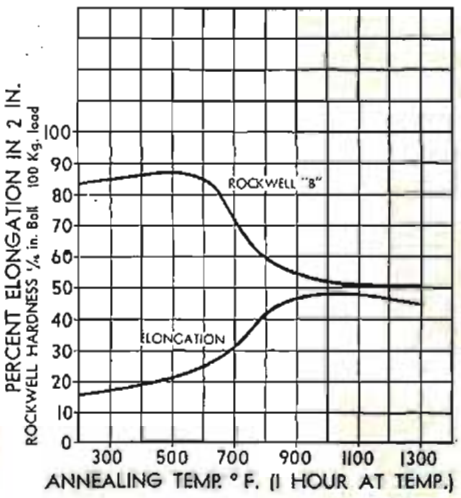


Rockwell B hardness, elongation of Manganese Bronze Rod previously extruded

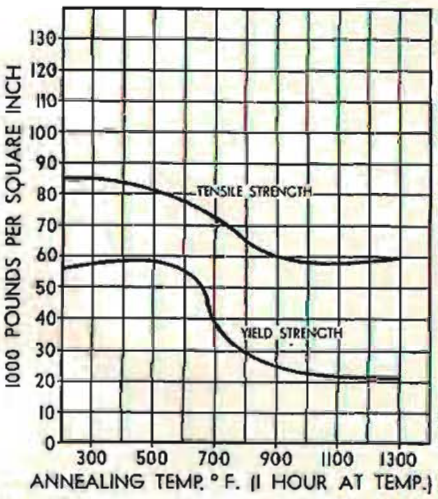


tensile strength, yield strength (0.5%) of Roman Bronze rod previously annealed to a grain size of 0.025 mm.

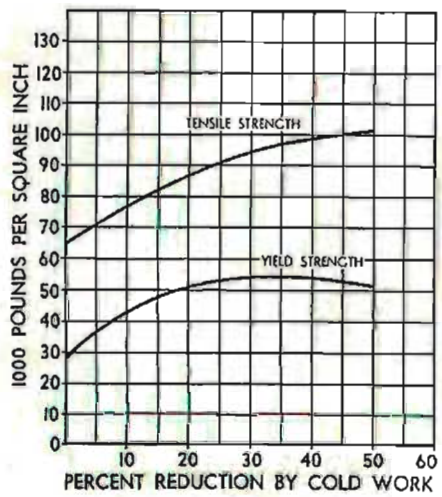
annealing



Rockwell B hardness, elongation of Roman Bronze rod previously cold worked 28% from material having a grain size of 0.025 mm.

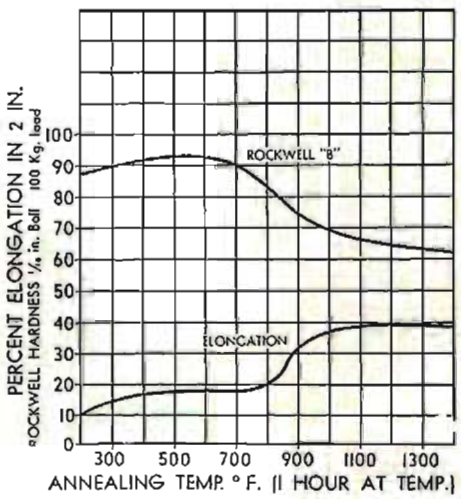


tensile strength, yield strength (0.5%) of Roman Bronze rod previously cold worked 28% from material having a grain size of 0.025 mm.

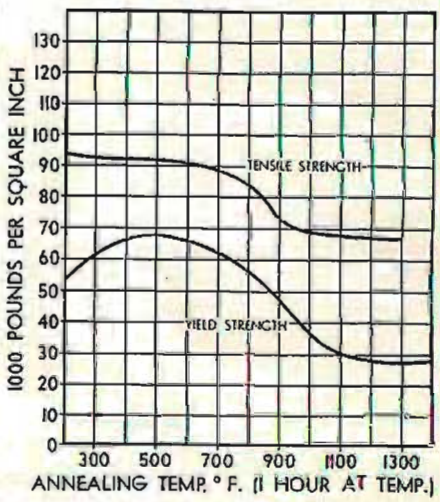


tensile strength, yield strength (0.5%) of Manganese Bronze rod previously extruded.

annealing



Rockwell B hardness, elongation of Manganese Bronze rod previously cold worked 30%.



tensile strength, yield strength (0.5%) of Manganese Bronze rod previously cold worked 30%.

→ the charts at small scale on these pages are intended to indicate range of properties and not to present exact data.

Revere Bronze Alloys

The bronzes shown in this section are not the only bronze alloys fabricated by Revere—nor do they cover the full range of alloys designated as "bronze." The term "bronze" is so generally used that, when a bronze is required, complete alloy specification should be given. Generally, bronzes are *engineering* alloys with higher mechanical properties than copper-zinc and copper-lead alloys. Because of superior fatigue resistance, they are used in operations requiring resistance to alternating and cyclic stresses.

silicon bronzes *(Herculoy 418, 419, 420, 421)* ● Gold in color, Herculoy alloys possess strength comparable to that of low and medium carbon steels. Corrosion resistance is similar to that of copper. They are non-magnetic, hot-work readily. Successfully welded by any of the commercial processes *(see page 54)*. Herculoy, when work-hardened to give maximum tensile strength and hardness, can be heat-treated to relieve internal stresses—without sacrifice of strength or hardness and with increase in elastic limit and yield strength.

Herculoy 418 and 420, with higher silicon content, have greater tensile strength and hardness than 419 and 421; used for welded tanks, chemical equipment, etc. Herculoy 419 and 421, with lower tensile strength, are more ductile and have unusually good cold-working and hot-working properties; used for cold-headed bolts, nuts, screws, lag bolts, etc. Better suited for intricate forgings than 418 and 420.

aluminum bronzes ● Revere Aluminum Bronzes are high copper alloys with 4 to 7.75% aluminum. Revalon, Aluminum Brass, alloy 435, also belongs to this group. They possess greater resistance to scaling at elevated temperatures than other copper-base alloys. Exposed surfaces of aluminum bronzes develop an oxide film highly resistant to mineral acids. Aluminum bronzes do not possess good resistance to strong alkalies.

Wrought aluminum bronzes are used where both high tensile strength and good corrosion resistance are needed: valve stems, propeller blade parts, bolts. Also where high strength and good wear-resistance are required: slide levers, bushings.

tin bronzes ● Revere Phosphor Bronzes are true tin bronzes containing 1¼ to 10% tin: grade A, 5%; grade C, 8%; grade D, 10%; grade E, under 4%. They have high tensile properties, excellent cold-working properties, unusual resistance to fatigue, low coefficient of friction, and corrosion resistance similar to that of copper. Phosphorus is used as deoxidant to prevent formation of oxide films at grain boundaries. Thus these alloys can be used at maximum strength and fatigue resistance.

Grade A (5%) and C (8%)—Springs; diaphragms; bellows. Lock washers; cotter pins; fuse clips; clutch discs; perforated sheets. Screw machine stock, bushings, etc. Grade D (10%)—Extra spring qualities and wear resistance. Grade E (under 4%)—Heavy bars and plates for severe compression, wear and corrosion, for bridge and expansion plates.

	silicon bronze			
alloy name	**Herculoy**		**Herculoy**	
Revere alloy number	418		419	
chemical composition: copper	96.5		97.75	
chemical composition: zinc	Si 3.0		Si 2.0	
chemical composition: lead	..		..	
chemical composition: nickel	..		..	
chemical composition: tin	0.5		0.25	
typical uses	tanks—pressure vessels steam pressure not to exceed 125 lbs. vats—baskets—marine construction weatherstrips, forgings, conduits hydraulic pressure lines		cold working—cold headed bolts, nuts, screws, lag bolts—hydraulic pressure line—cable clamps cotter pins	
general properties	corrosion resistance of copper mechanical properties of mild steel		tensile properties comparable to 70-30 brass, corrosion resistance similar to that of copper; welding properties only slightly inferior to 418; non-magnetic	
working properties 1. cold-working	1. good		1. excellent	
2. hot-working	2. excellent		2. excellent	
3. machining	3. fair		3. fair	
4. welding	4. gas, carbon arc, metal arc—spot and seam for thin gauge		4. gas, carbon arc, metal arc—spot and seam for thin gauge	
5. soldering	5. excellent		5. excellent	
6. polishing	6. fair		6. fair	
physical properties density lb per cu in.	0.308		0.316	
Young's modulus of elasticity, psi, (000,000 omitted)	15.0		15.0	
melting point °F	1880		1990	
coefficient of thermal expansion per °F, (68 to 570°F)	.0000100		.0000099	
electrical conductivity, % IACS at 68°F	8.1		11.0	
thermal conductivity Btu per sq ft, per ft, per hr, per °F at 68°F	27		31	
	hard	*soft*	*hard*	*soft*
tensile strength in 1000 lb per sq in.: sheet	100	60	90	49
tensile strength in 1000 lb per sq in.: rod	85	65	70	45
tensile strength in 1000 lb per sq in.: tube	..	..	95	48
elongation % in 2 in.: sheet	5	55	10	55
elongation % in 2 in.: rod	30	65	20	60
elongation % in 2 in.: tube	..	..	5	40
yield strength 0.5% extension under load 1000 lb per sq in.: sheet	..	..	..	..
yield strength 0.5% extension under load 1000 lb per sq in.: rod	..	..	50	15
yield strength 0.5% extension under load 1000 lb per sq in.: tube	..	..	..	..
Rockwell hardness no.: sheet	95B	50B	85B	65F
Rockwell hardness no.: rod	90B	50B	85B	60F
Rockwell hardness no.: tube	..	..	90B	60F
ASTM specifications: sheet	B96 B97	B97 ..	B97 ..	
ASTM specifications: rod	B98 B124	.. ..	B98 B124	
ASTM specifications: tube	..	..	..	
for further data, see	*page 32*			

	aluminum bronze				tin bronze					
	Herculoy		Herculoy		Aluminum Bronze, 5%		Aluminum Silicon Bronze		Phosphor, grade "A"	
	420		421		429		436		308	
	98.25 Si 3.0 .. .. min. 1.0		98.25 Si 1.5 .. .. min. 0.25		95.0 Al 5.0		91.0 Al 7.0 Si 2.0		95.0 P 0.05 .. .. 5.0	
	similar to 418		similar to 419		condenser tubes high strength forgings tie bolts hardware bushings		bolts, nuts, gears, pinions, valve bushings valve bodies and stems marine hardware, sucker rods		diaphragms, bellows, lock washers, cotter pins, fuse clips, clutch discs, springs, screw machine stock	
	similar to 418		similar to 419		high physical properties high resistance to acids most resistant of the bronzes to H_2S		unusually high tensile strength excellent corrosion resistance readily hot forged, rolled and extruded free machining		high tensile strength high resistance to corrosion and fatigue low friction coefficient; high immunity to season cracking	
	1. good 2. excellent 3. fair 4. gas, carbon arc, metal arc—spot and seam for thin gauge 5. excellent 6. good		1. excellent 2. excellent 3. fair 4. gas, carbon arc, metal arc—spot and seam for thin gauge 5. excellent 6. fair		1. good 2. good 3. fair 4. gas, carbon arc, metal arc 5. good 6. good		1. poor 2. excellent 3. excellent 4. gas, carbon arc, metal arc 5. fair 6. excellent		1. excellent 2. poor 3. fair 4. gas, carbon arc, metal arc—spot and seam for thin gauge 5. excellent 6. excellent	
	0.308		0.316		0.295		0.278		0.320	
	15.0		15.0		17.5		16.8		15.0	
	1878		1940		1950		1814		1922	
	.0000100		.0000099		.0000099		.0000092		.0000099	
	6.5		11.6		17.7		7.0		18.4	
	19		31		48		22		47	
	hard	soft	hard	soft	hard	soft	hard ■	soft	hard	soft
	100 85 ..	60 65 ..	90 70 95	40 45 48	.. 85 70	.. 65 50	.. 95 ..	.. 85 ..	80	45 .. ..
	5 20 ..	55 65 ..	10 20 5	55 60 40	.. 20 25	64 60 60	.. 25 ..	.. 35 ..	5	50 .. ..
	..	..	..	..	..	..	..	..	70	15
	..	..	50	15	55	20	53	43	..	..
	..	..	..	..	..	..	..	..	..	..
	95B 90B ..	50B 50B ..	90B 85B 90B	65F 60F 60F	.. 85B 80B	72F 40B 55F	.. 82B ..	.. 75B ..	85B	25B .. ..
	B96 B97		B97 ..		..		..		B103	
	B98 B124		B98 B124		B124		..		..	
	..		..		B111		..		..	
			page 32				page 34		page 34	

	bearing bronze
	Phosphor, grade "C"	Bearing Bronze
	315	325
	92.0 P 0.05 .. .. 8.0	90.0 copper 9.5 zinc .. .. 0.50 tin
	springs, perforated sheets, bellows, cotter pins, fuse clips, bushings lock washers	bushing material for light loads weatherstrip applications fuse clips lamp connections
	corrosion and fatigue resistance high friction coefficient low high tensile strength	high physical properties resistant to atmospheric corrosion and tarnish low friction coefficient
	1. excellent 2. poor 3. fair 4. gas, carbon arc, metal arc—spot and seam for thin gauge 5. excellent 6. excellent	1. excellent 2. excellent if lead-free 3. fair 4. gas, carbon arc, metal arc 5. excellent 6. excellent
	0.318	0.315
	15.0	15.0
	1875	1860
	.0000101	.0000102
	13.0	39.0
	36	100
	hard	soft	hard	soft
	85	55	65	45 .. ..
	10	60	5	42 .. ..
	.. .. ..	.. .. ..	57	10 .. ..
	90B	40B	76B	55F .. ..
	B103 ..		..	
	.. ..		..	
	..		..	
	page 34			

Tests on 325 conducted on 0.040 in. stock. Basis of rating: *hard* on material previously rolled 6 B&S nos. Grain at ready to finish .080-.150 mm. *soft* annealed at 1300°F for one hour.

■ hard refers to final reduction of 10%; soft, extruded condition only

Herculoy

alloy	copper	silicon	tin	manganese
418	96.50%	3.0%	0.5%	—
421	98.25%	1.5%	—	0.25%

forms available: sheet, strip, plate, rod, wire, tube, forgings

general properties • Revere Herculoy has excellent mechanical properties. The strength of Herculoy is comparable to that of low and medium carbon steel. Its resistance to corrosion is similar to that of copper. These alloys are non-magnetic and gold colored.

typical uses • Herculoy is recommended for tanks, pressure vessels (unfired pressure vessels codes), vats, baskets, hardware, bolts, screws, lag screws, cotter pins, washers, turnbuckles, marine construction, shafting, plates, screens, filters, ducts, weatherstrips, springs, forging, electrical conduit.

physical properties	418 (sheet)		421 (rod)	
	hard ■	soft □	hard •	soft □
tensile strength, psi (000 omitted)	100	60	70	45
elongation, % in 2 in.	5	55	20	60
yield strength, 0.5% extension, psi (000 omitted)	—	—	50	15
Rockwell hardness	95B	50B	85B	60F
density, lb. per cu in.	0.308		0.316	
average coefficient of thermal expansion, per °F, (68 to 570°F)	0.0000100		0.0000099	
electrical conductivity, % IACS, at 68°F	8.1		11.0	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	27		31	

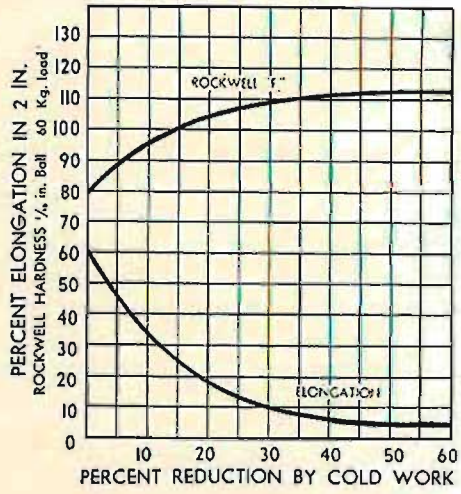
■ based on material previously rolled four B&S numbers hard (37.5% area reduction)
• based on a final reduction of area of 25%
□ based on a grain size of 0.035 mm.
all tests conducted on 0.040 in. strip or rod under 1 in. in diameter

working properties • Cold-working, soldering — excellent. Hot-working—good. Machining, polishing—fair. Welding—see page 54.

ASTM specifications • Sheet: B-96, B97. Rod: B98, B124.

alloy no. 418

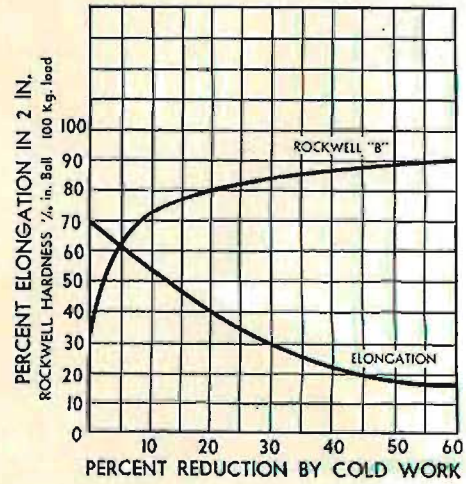
sheet cold working



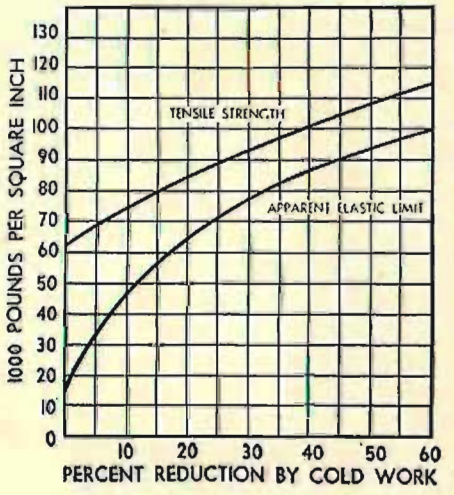
Rockwell F hardness, elongation of 418 Herculoy strip previously annealed to a grain size of 0.080 mm.

alloy no. 421

rod cold working

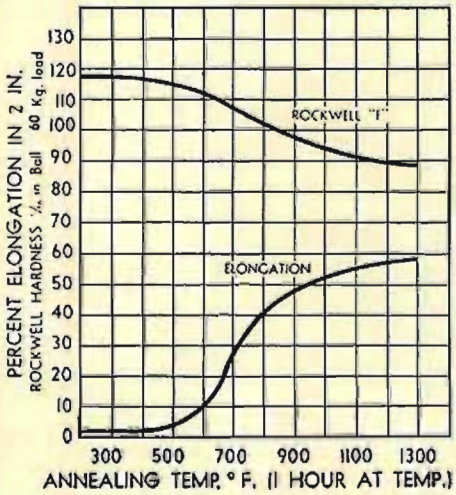


Rockwell B hardness, elongation of 418 Herculoy strip previously annealed to a grain size of 0.080 mm.

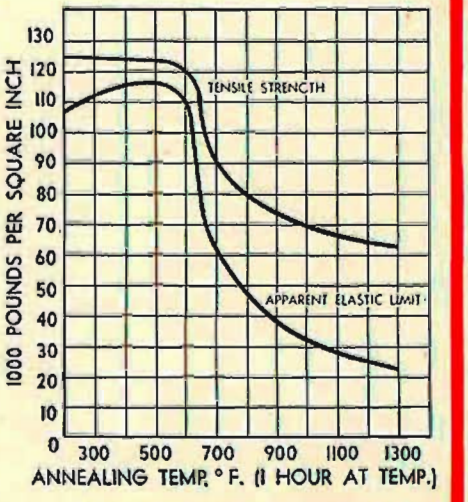


tensile strength, apparent elastic limit of 418 Herculoy strip previously annealed to a grain size of 0.080 mm.

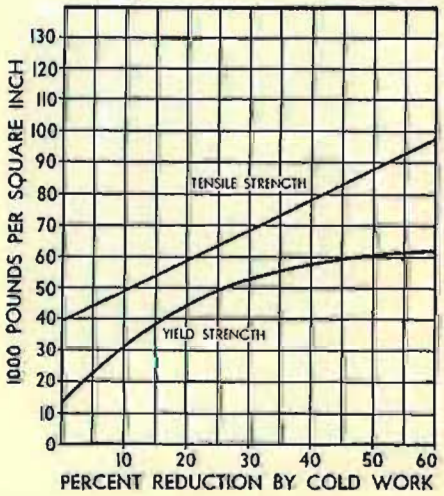
annealing



Rockwell F hardness, elongation of 418 Herculoy strip previously rolled 67% from material having a grain size of 0.080 mm.

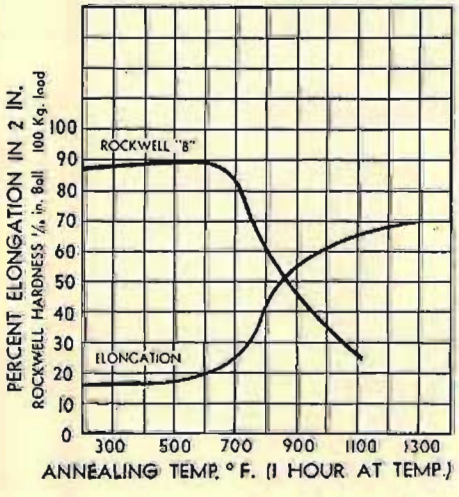


tensile strength, apparent elastic limit of 418 Herculoy strip previously rolled 67% from material having a grain size of 0.080 mm.

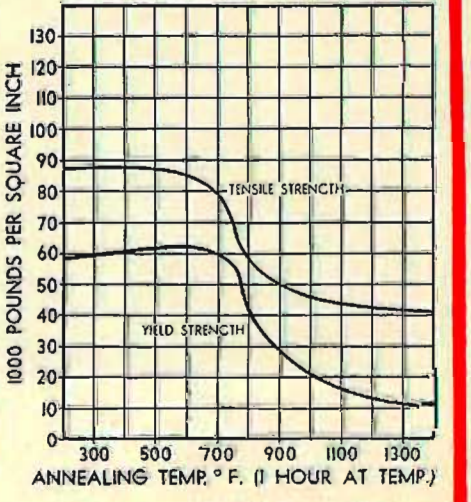


tensile strength, yield strength (0.5%) of 421 Herculoy rod previously annealed to a grain size of 0.115 mm.

annealing



Rockwell B hardness, elongation of 421 Herculoy rod previously cold worked 50% from material having a grain size of 0.115 mm.



tensile strength, yield strength (0.5%) of 421 Herculoy rod previously cold worked 50% from material having a grain size of 0.115 mm.

→ the charts at small size on these pages are intended to indicate range of properties and not to present exact data

Phosphor Bronze, grade A

alloy no. 308

copper 95.0% *phosphorus 0.05%* *tin 5.0%*

available in sheet, strip and rod

general properties ● Revere Phosphor Bronze, grade A, possesses high tensile strength, high resistance to corrosion and fatigue and has a low friction coefficient. It is also highly resistant to season cracking.

typical uses ● Revere Phosphor Bronze, grade A, is used for springs, diaphragms, bellows, lock washers, cotter pins, fuse clips, clutch discs, screw machine stock, perforated sheets, etc.

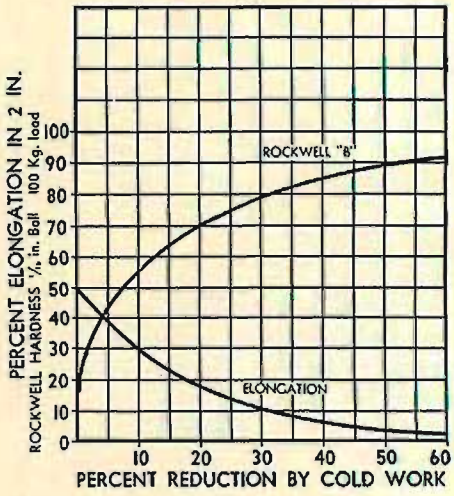
physical properties (sheet)	hard ■	soft □
tensile strength, psi (000 omitted)	80	45
elongation, % in 2 in.	5	50
yield strength, 0.5% extension, (000 omitted)	70	15
Rockwell hardness	85B	25B
density, lb per cu in.	0.302	
average coefficient of thermal expansion, per °F, (68-570°F)	0.0000099	
electrical conductivity, % IACS, at 68°F	18.4	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	47	

■ based on material previously rolled four B&S numbers hard (37.5% area reduction)
□ based on final grain size of 0.035 mm.
all tests conducted on 0.040 in. stock.

working properties ● Cold-working, soldering, polishing—excellent. Hot-working—poor. Machining—fair. Welding—see page 57.

ASTM specifications ● Sheet: B103.

sheet cold working



Rockwell B hardness, elongation of grade A Phosphor Bronze strip previously annealed to a grain size of 0.070 mm.

Aluminum Bronze

alloy no. 436 Aluminum Silicon Bronze

copper 91.0% *aluminum 7.0%* *silicon 2.0%*

forms available: rod and forgings

general properties ● Unusually high strength, excellent corrosion resistance, free machining, good wear resistance, low coefficient of friction with steels, excellent forging.

typical uses ● Revere Aluminum Bronze is excellent for bolts, nuts, tie rods, gears, pinions, thrust screws, bushings, sliding parts, forged valve bodies, valve stems, compression fittings, sucker rods, automobile synchronizer cones, gear followers.

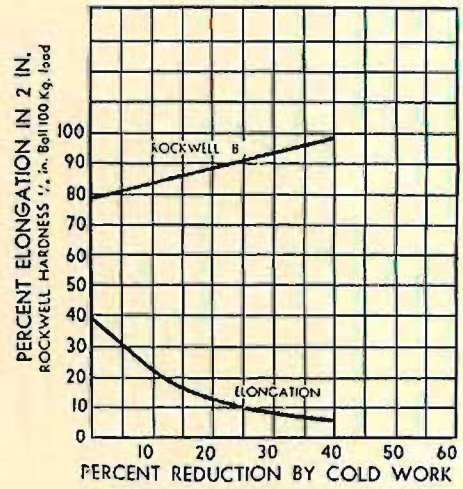
physical properties (rod)	hard ■	soft □
tensile strength, psi (000 omitted)	100	90
elongation, 2% in 2 in.	25	35
yield strength, 0.5% extension, psi (000 omitted)	53	43
Rockwell hardness	82B	75B
density, lb per cu in.	0.278	
average coefficient of thermal expansion, per °F, (68-570°F)	0.0000092	
electrical conductivity, % IACS, at 68°F	7.0	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	22	

■ based on a final area reduction of 25%.
□ as extruded.
all tests conducted on rod under 1 in. in diameter

working properties ● Cold-working—poor. Hot-working, machining, polishing—excellent. Soldering—fair. Welding—see page 52.

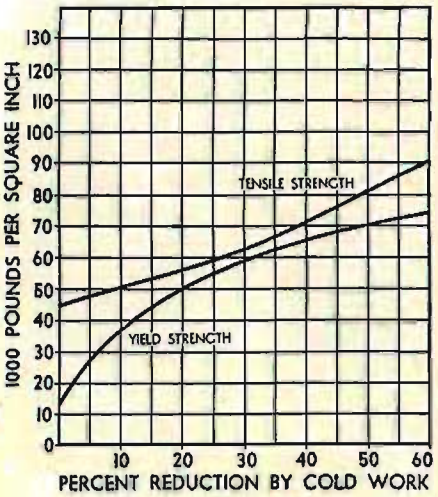
ASTM specifications ● Rod: B150.

rod cold working

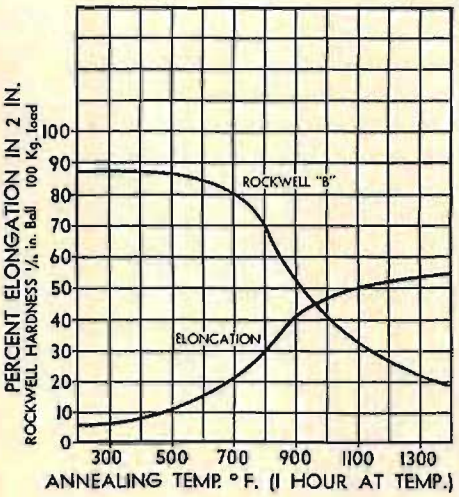


Rockwell B hardness, elongation of Aluminum Silicon Bronze rod previously annealed to a grain size of 0.030 mm.

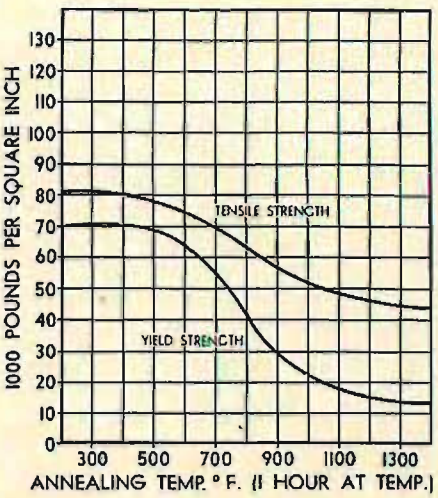
annealing



tensile strength, yield strength (0.5%) of grade A Phosphor Bronze strip previously annealed to a grain size of 0.070 mm.

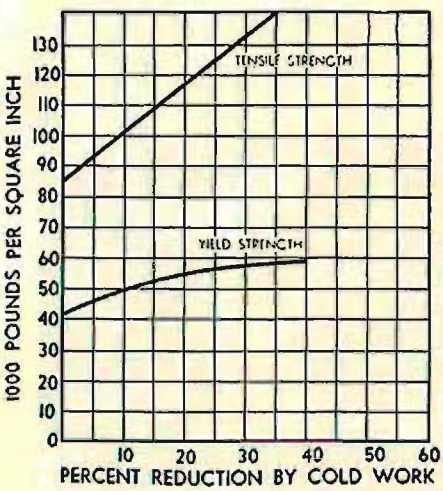


Rockwell B hardness, elongation of grade A Phosphor Bronze strip previously cold rolled 50% from material having a grain size of 0.070 mm.

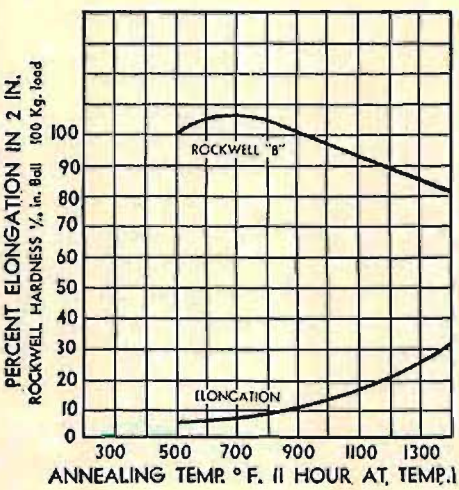


tensile strength, yield strength (0.5%) of grade A Phosphor Bronze strip previously cold rolled 50% from material having a grain size of 0.070 mm.

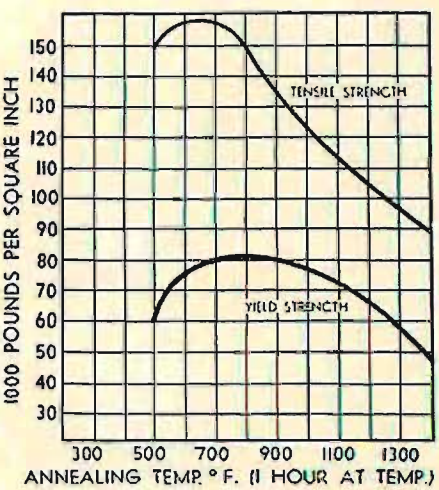
annealing



tensile strength, yield strength (0.5%) of Aluminum Silicon Bronze rod previously annealed to a grain size of 0.030 mm.



Rockwell B hardness, elongation of Aluminum Silicon Bronze rod previously cold worked 40% from material having a grain size of 0.030 mm.



tensile strength, yield strength (0.5%) of Aluminum Silicon Bronze rod previously cold worked 40% from material having a grain size of 0.030 mm.

→ the charts at small scale on these pages are intended to indicate range of properties and not to present exact data.

Revere Nickel Alloys

Alloys are of two basic types: the copper-nickel zinc alloys known as the Nickel Silvers; and the copper-nickel alloys or Cupro-Nickels.

Nickel Silvers

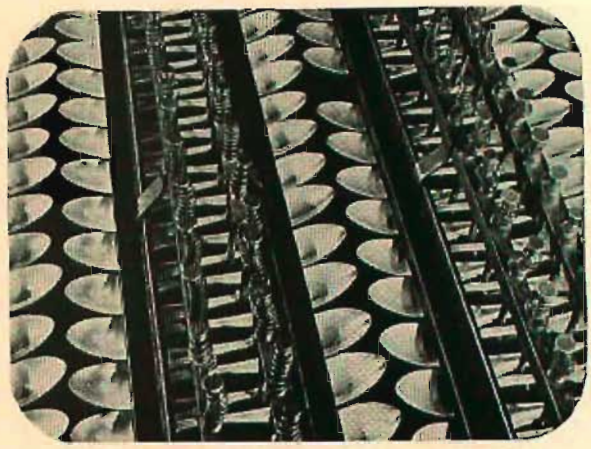
Nickel is added to the copper-zinc primarily for its influence on color. When the nickel content is high, the color is silver-white; as the nickel content is reduced, the color becomes slightly warmer. The addition of nickel also improves mechanical properties and greatly increases resistance to corrosion and tarnish.

The Nickel Silver alloys can be divided into two general types: *single-phase structure* alloys contain approximately 65% copper and 5 to 20% nickel. They possess excellent cold-working and only fair hot-working properties. They are most frequently used in applications requiring ductility in the cold condition—for articles to be plated, such as tableware and hollow ware. Lead is frequently added to improve machining, blanking and shearing. In this group are alloys 533, 535, 545, 548, 575.

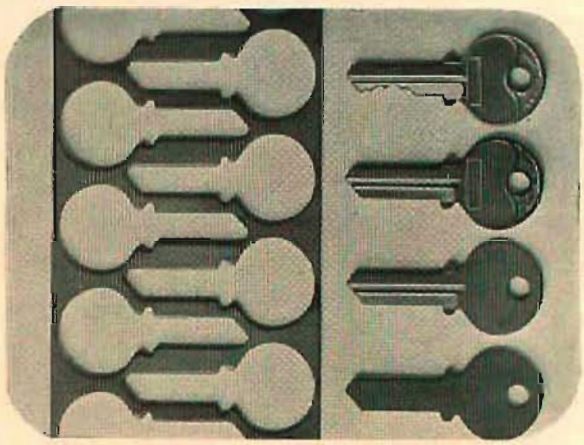
Two-phase alpha-beta structure alloys contains 55 to 60% copper and varying amounts of nickel. They are readily hot worked; can be fabricated into difficult, intricate shapes such as plumbing fixtures, architectural shapes, etc. Lead may be added to improve machining. Alloy 555, of this group, is used extensively as spring material—due to higher tensile properties combined with higher modulus of elasticity than found in any other nickel silvers.

Cupro-Nickels

These alloys, single-phase solutions of copper and nickel, are available in two types: 80% copper and 20% nickel, and 70% copper and 30% nickel. These alloys fill the demand for condenser tubes and plates capable of resisting the erosive-corrosive attack of high velocity salt water used as coolant in Navy surface condensers. Tensile properties are similar to those of 70-30 Brass. They are the most resistant of the copper-base alloys to failure by stress-corrosion and corrosion fatigue. The 70-30 Cupro-Nickel is the superior condenser tube alloy and is widely used where conditions are most severe. The 80-20 Cupro-Nickel is for less severe conditions. In rod form, the Cupro-Nickels are used for bolts, nuts, screws and similar parts manufactured by cold-heading. In strip form, they are used in ammunition components.



Nickel silver provides an ideal base for plated tableware and hollow ware.



Leaded nickel silver is used extensively for key blanks.

Condenser tubes of cupro-nickel are highly resistant to both erosive and corrosive attack.

d nickel alloys

alloy name	18% Nickel Silver *Deep Drawing*		18% Nickel Silver *Spring Stock*		15% Nickel Silver		10% Nickel Silver		5% Nickel Silver		Nickel Silver (Leaded)		Cupro-Nickel 30%	
Revere alloy number	533		555		535		545		548		575		510	
composition: copper	65.5		55.0		66.0		66.0		62.0		66.0		70.0	
composition: zinc	16.5		27.0		19.0		24.0		33.0		20.0		..	
composition: lead	..		..		..		..		..		2.0		..	
composition: nickel	18.0		18.0		15.0		10.0		5.0		12.0		30.0	
composition: tin	..		..		..		..		..		..		..	
typical uses	marine and automotive trim, hardware, architectural panels and extruded shapes, lighting, electrical and plumbing fixtures, camera parts, various equipment in the process industries slide fasteners, tableware, jewelry, stamping, etching		springs, marine and automotive trim, hardware architectural panels and extruded shapes lighting, electrical and plumbing fixtures, various equipment in the process industries tableware, jewelry, stamping, etching		hollow ware panel sheet to match complimentary trim		inexpensive jewelry hollow ware (dishes and trays) stampings embossings decorative trim		inexpensive jewelry for color decorative trim		keys products requiring machinability lock washers cotter pins fuse clips		condenser tubes and plates, tanks, vats, vessels process equipment automotive parts nuts, bolts, screws, meters, refrigerator pump valves	
general properties	high physical properties high resistance to corrosion and tarnish malleable and ductile color: silver-blue-white		high physical properties high resistance to corrosion and tarnish high fatigue strength color: blue-white		high physical properties high resistance to corrosion and tarnish malleable and ductile color: white		ductility deep drawing color: yellow-white		ductility deep drawing color: yellow-white		good machinability prefer non-leaded for bending and drawing color: white		high strength and physical properties high ductility resistant to corrosion and erosion color: white-silver	
working properties: cold working	excellent		good		good		excellent		excellent		poor		excellent	
working properties: hot working	fair		fair		fair		fair		fair		fair		fair	
working properties: machining	fair		fair		fair		fair		fair		excellent non-leaded pref.		gas, metal arc, resistance	
working properties: welding	△		△		△		△		△		excellent		excellent	
working properties: soldering	excellent		excellent		excellent		excellent		excellent		excellent		good	
working properties: polishing	excellent		excellent		excellent		excellent		excellent		excellent			
density, lb per cu in.	0.316		0.314		0.314		0.313		0.308		0.314		0.323	
Young's modulus of elasticity, psi (000,000 omitted)	18.0		18.0		18.0		17.0		16.0		17.0		22.0	
melting point, °F	2030		1930		1965		1850		1760		1900		2250	
average coefficient of thermal expansion, per °F (68 to 570°F)	.0000082		.0000083		.0000083		.0000083		....		.0000083		.0000089	
electrical conductivity, % IACS at 68°F	6.0		5.6		6.3		8.4		12.0		7.4		4.7	
thermal conductivity, Btu, per sq ft, per ft, per hr, per °F at 68°F	19		18		20		27		34		23		17	
	hard	*soft*	*hard*	*soft*	*hard*	*soft*	*hard*	*soft*	*hard*	*soft*	*hard*	*soft*	*hard*	*soft*
tensile strength psi (000 omitted): sheet ■	84	58	105	65	84	55	86	55	85	55	78	55	78	54
tensile strength psi (000 omitted): rod □	..	..	..	..	..	..	..	..	..	..	..	..	75	54
tensile strength psi (000 omitted): tube	..	..	..	..	..	..	..	..	..	..	..	..	80	50
elongation % in 2 in.: sheet ■	5	35	5	35	5	40	5	40	5	60	5	40	5	35
elongation % in 2 in.: rod □	..	..	..	..	..	..	..	..	..	..	..	..	15	45
elongation % in 2 in.: tube	..	..	..	..	..	..	..	..	..	..	..	..	5	45
yield strength 0.5% extension under load 1000 psi: sheet ■	78	22	90	28	75	20	75	20	68	20	75	18	75	16
yield strength 0.5% extension under load 1000 psi: rod □	..	..	..	..	..	..	..	..	..	..	..	..	72	18
yield strength 0.5% extension under load 1000 psi: tube	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rockwell hardness: sheet ■	68B	45B	95B	55B	85B	40B	85B	35B	85B	35B	82B	35B	85B	40B
Rockwell hardness: rod □	..	..	..	..	..	..	..	..	..	..	..	..	80B	35B
Rockwell hardness: tube	..	..	..	..	..	..	..	..	..	..	..	..	82B	39B
ASTM specifications: sheet ■	B122		B122				B122						B122	
ASTM specifications: rod □													B111	
ASTM specifications: tube														
for further data, see	*page 38*		*page 38*								*page 40*		*page 40*	

■ basis of rating: *hard*, on material previously rolled 4 B & S numbers hard (37.5% area reduction); *soft*, on final grain size of 0.035 mm. (all tests conducted on 0.040 stock.)

□ basis of rating: *hard*, on final area reduction of 25%; *soft*, on final grain size of 0.035 mm. (all tests conducted on rod under 1-inch diameter.)

△ gas, carbon arc, metal arc, spot and seam welding for thin gauge.

Nickel Silver (deep drawing)

alloy no. 533

copper 65.5% *nickel 18.0%* *zinc 16.5%*

forms available: sheet, strip, lockseam tubing

general properties • Revere Nickel Silver has high resistance to corrosion and tarnish. It is also malleable and ductile.

typical uses • Nickel Silver is recommended for marine and automotive trim, hardware; architectural panels and extruded shapes; lighting, electrical and plumbing fixtures; various equipment of the process industries; tableware, jewelry, stamping and etching.

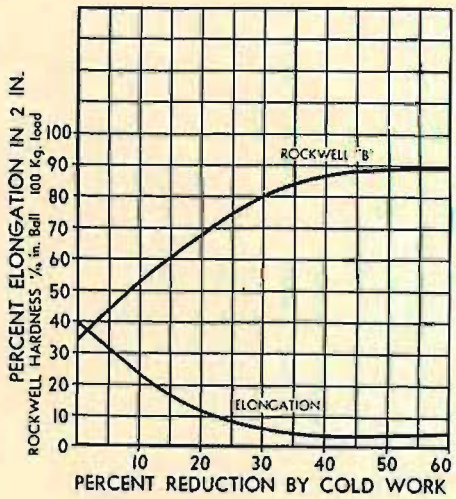
physical properties (sheet, strip)	hard ■	soft □
tensile strength, psi (000 omitted)	84	58
elongation, % in 2 in.	5	35
yield strength, 0.5% extension psi (000 omitted)	78	22
Rockwell hardness	88B	45B
density, lb per cu in.	0.316	
average coefficient of thermal expansion per °F. (68-570°F)	.000082	
electrical conductivity, % IACS, at 68°F	6.0	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	19	

■ based on material previously rolled four B&S numbers hard (37.5% area reduction)
□ based on grain size of 0.035 mm.
all tests conducted on 0.040 in. stock.

working properties • Cold-working, soldering, polishing — excellent. Hot-working, machining—fair. Welding—see page 56.

ASTM specifications • Sheet: B122.

sheet cold working



Rockwell B hardness, elongation of 18% Nickel Silver strip previously annealed to a grain size of 0.070 mm.

Nickel Silver (spring stock)

alloy no. 555

also known as 18% nickel silver

copper 55.0% *nickel 18.0%* *zinc 27.0%*

forms available: strip, lockseam tubing

general properties • Revere Nickel Silver (spring stock) possesses high physical properties, high resistance to corrosion and tarnish and high fatigue strength.

typical uses • Nickel Silver (spring stock) is recommended especially for springs; also for marine and automotive trim, hardware; architectural panels and extruded shapes; lighting, electrical and plumbing fixtures; various equipment of the process industries; tableware, jewelry, stamping and etching.

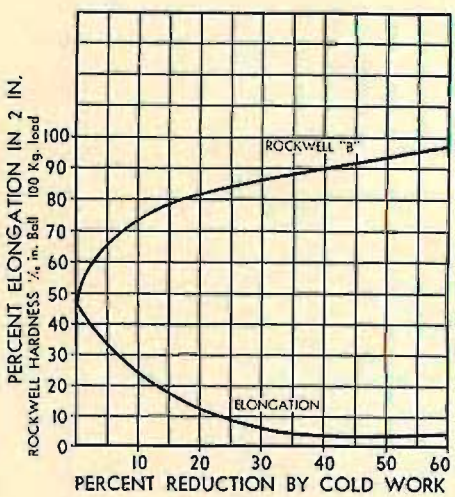
physical properties (sheet, strip)	hard ■	soft □
tensile strength, psi (000 omitted)	105	105
elongation, % in 2 in.	5	35
yield strength, 0.5% extension psi (000 omitted)	90	28
Rockwell hardness	95B	55B
density, lb per cu in.	0.314	
average coefficient of thermal expansion per °F, (68-570°F)	.000083	
electrical conductivity, % IACS, at 68°F	5.6	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	18	

■ based on material previously rolled four B&S numbers hard (37.5% area reduction)
□ based on grain size of 0.035 mm.
all tests conducted on 0.040 in. stock.

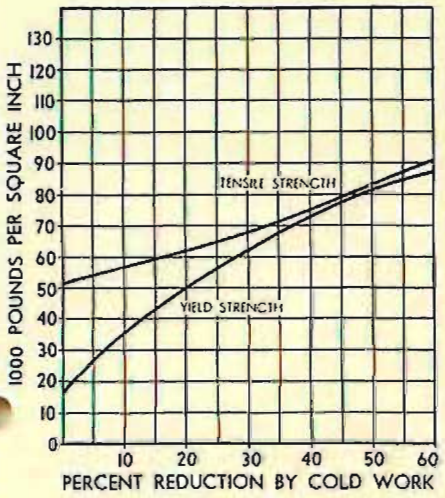
working properties • Cold-working, soldering, polishing—excellent. Hot-working, machining—fair. Welding—see page 56.

ASTM specifications • Sheet: B122.

sheet cold working

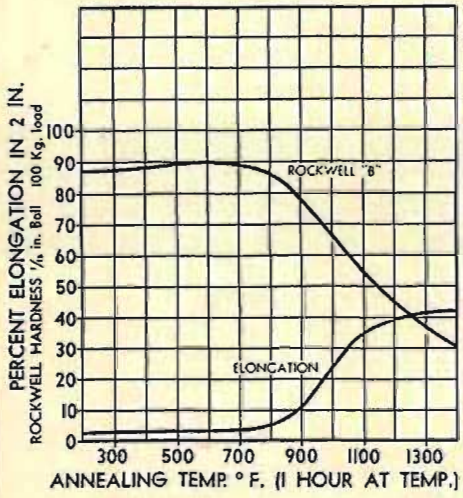


Rockwell B hardness, elongation of 18% (spring stock) Nickel Silver strip previously annealed to a grain size of 0.080 mm.

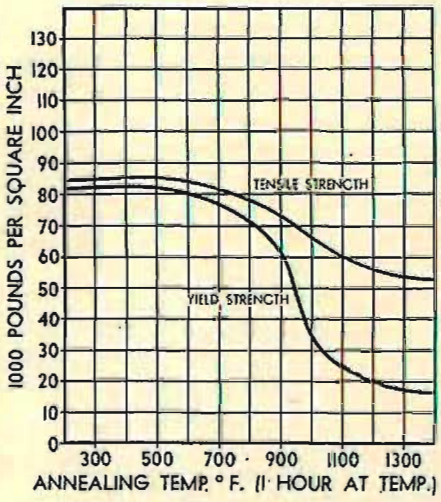


tensile strength, yield strength (0.5%) of 18% Nickel Silver strip previously annealed to a grain size of 0.070 mm.

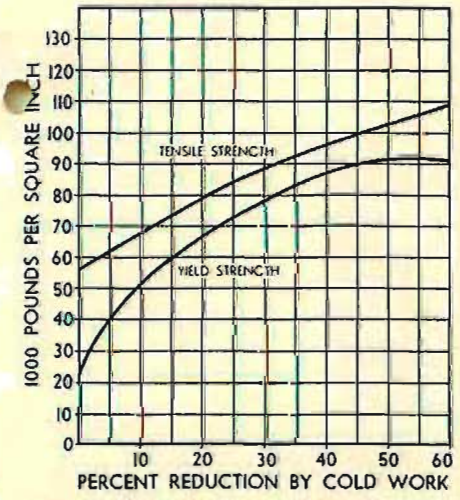
annealing



Rockwell B hardness, elongation of 18% Nickel Silver strip previously cold rolled 50% from material having a grain size of 0.070 mm.

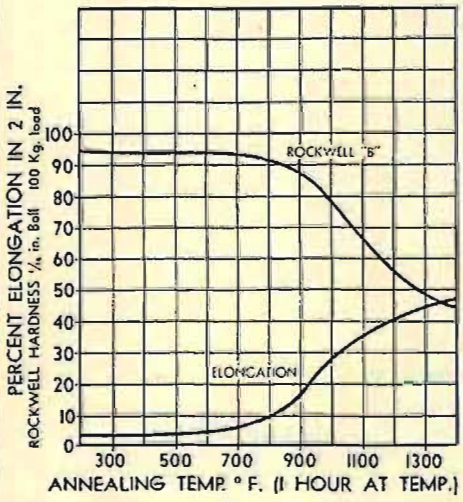


tensile strength, yield strength (0.5%) of 18% Nickel Silver strip previously cold rolled 50% from material having a grain size of 0.070 mm.

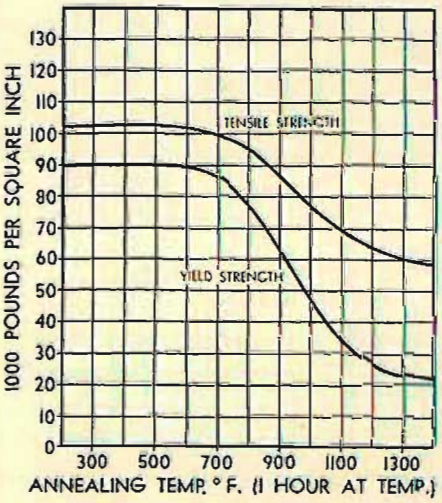


tensile strength, yield strength (0.5%) of 18% (spring stock) Nickel Silver strip previously annealed to a grain size of 0.080 mm.

annealing



Rockwell B hardness, elongation of 18% (spring stock) Nickel Silver strip previously cold rolled 50% from material having a grain size of 0.080 mm.



tensile strength, yield strength (0.5%) of 18% (spring stock) Nickel Silver strip previously cold rolled 50% from material having a grain size of 0.080 mm.

→ **the charts at small scale on these pages are intended to indicate range of properties and not to present exact data.**

Leaded Nickel Silver

alloy no. 575

copper 66.0% *lead 2.0%* *nickel 12.0%* *zinc 20.0%*

available in strip form only

general properties ● Revere Leaded Nickel Silver has good machinability, —but the non-leaded is preferred for bending and drawing. The color is white.

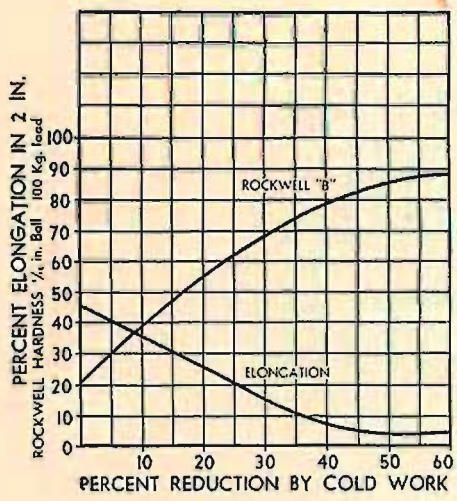
typical uses ● Leaded Nickel Silver is recommended for keys, lock washers, cotter pins, fuse clips and products that require machinability.

physical properties	hard ■	soft □
tensile strength, psi (000 omitted)	78	55
elongation, % in 2 in.	5	40
yield strength, 0.5% extension psi (000 omitted)	75	18
Rockwell hardness	82B	35B
density, lb per cu in.	0.314	
average coefficient of thermal expansion per °F, (68-570°F)	.000083	
electrical conductivity, % IACS, at 68°F	7.4	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	23	

■ based on material previously rolled 4 B&S numbers hard (37.5% area reduction)
□ based on grain size of 0.035 mm.
all tests conducted on 0.040 in. stock.

working properties ● Cold-working—poor. Hot-working—fair. Machining, polishing, soldering—excellent. Welding—non-leaded preferred.

sheet **cold working**



Rockwell B hardness, elongation of leaded Nickel Silver strip previously annealed to a grain size of 0.060 mm.

Cupro-Nickel

alloy no. 510

copper 70.0% *nickel 30.0%*

forms available: sheet, strip, plate, rod, tube

general properties ● Revere Cupro-Nickel, 30%, possesses many desirable qualities. Its mechanical properties make it strong enough for many applications where ferrous alloys may be used. Its ductility offers excellent cold-working qualities. Its chemical composition makes for resistance to many corrosive and erosive agents, and the white-silver color is very attractive.

This alloy may be drawn, stamped, cold forged and otherwise submitted to severe drawing and bending operations. It can also be hot forged and readily welded, brazed or soldered.

typical uses ● Revere Cupro-Nickel is used for tubes and plates in condensers of modern ships and power plants. Also for tanks, vats, vessels and general industrial and chemical uses. Used for automobile parts, meter parts, refrigerator parts, pump valves.

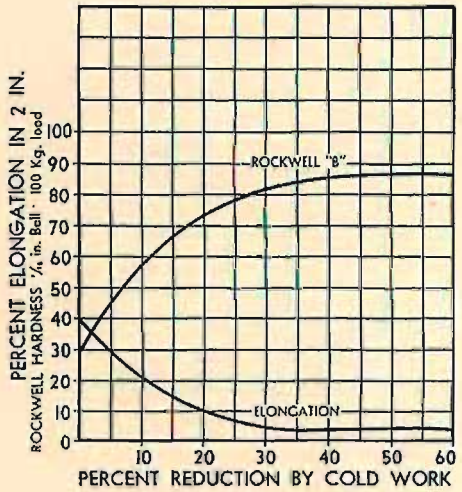
physical properties (sheet, strip)	hard ■	soft □
tensile strength, psi (000 omitted)	78	54
elongation, % in 2 in.	5	35
yield strength, 0.5% extension psi (000 omitted)	75	16
Rockwell hardness	85B	40B
density, lb per cu in.	0.323	
average coefficient of thermal expansion per °F, (68-570°F)	0.000089	
electrical conductivity, % IACS, at 68°F	4.7	
thermal conductivity, Btu per sq ft, per ft, per hr, per °F, at 68°F	17	

■ based on material previously rolled four B&S numbers hard (37.5% area reduction)
□ based on grain size of 0.035 mm.
all tests conducted on 0.040 in. stock.

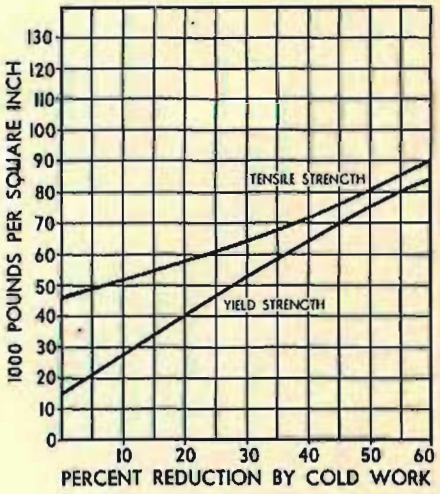
working properties ● Cold working, soldering—excellent. Hot-working, machining—fair. Polishing—good. Welding—see page 53.

ASTM specifications ● Sheet: B122. Tube: B111.

sheet **cold working**

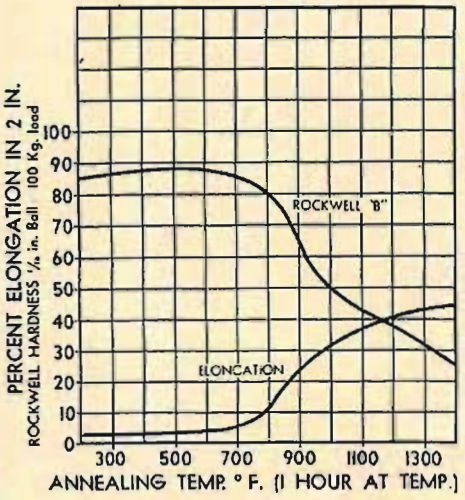


Rockwell B hardness, elongation of 70-30 Cupro-Nickel strip previously annealed to a grain size of 0.070 mm

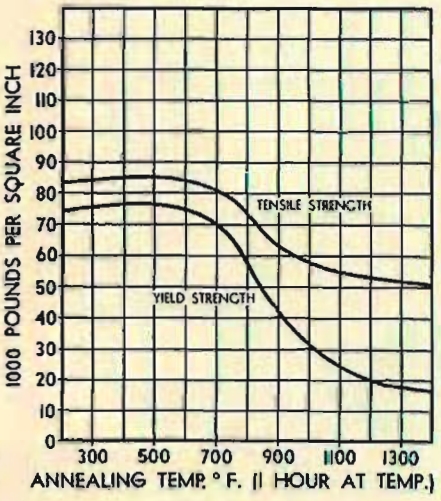


tensile strength, yield strength (0.5%) of leaded Nickel Silver strip previously annealed to a grain size of 0.060 mm.

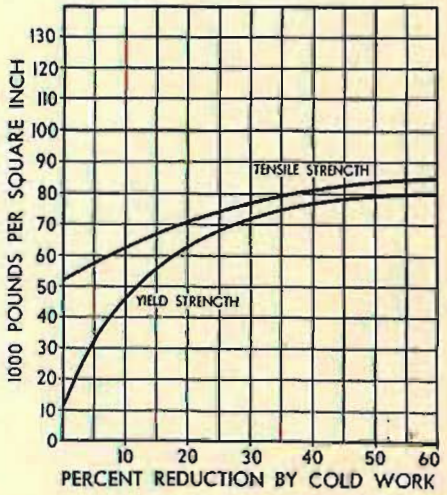
annealing



Rockwell B hardness, elongation of leaded Nickel Silver strip previously cold rolled 50% from material having a grain size of 0.060 mm.

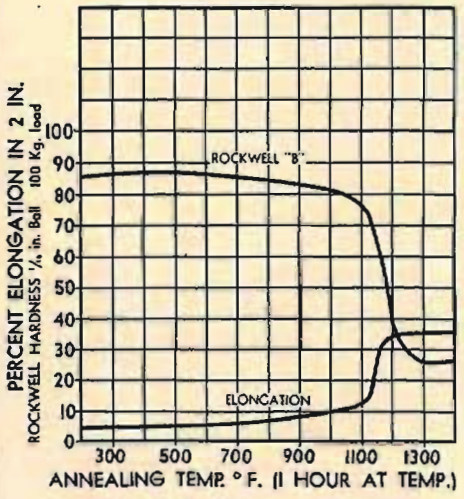


tensile strength, yield strength (0.5%) of leaded Nickel Silver strip previously cold rolled 50% from material having a grain size of 0.060 mm.

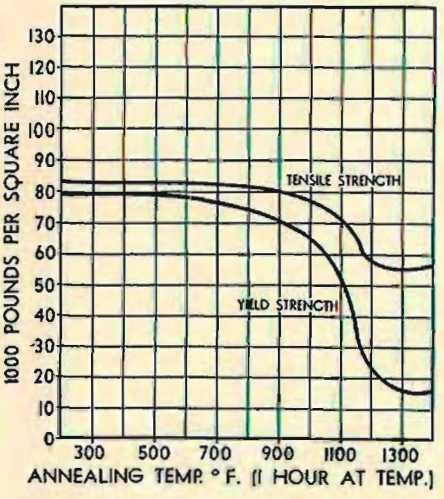


tensile strength, yield strength (0.5%) of 70-30 Cupro-Nickel strip previously annealed to a grain size of 0.070 mm.

annealing



Rockwell B hardness, elongation of 70-30 Cupro-Nickel strip previously cold rolled 50% from material having a grain size of 0.070 mm.



tensile strength, yield strength (0.5%) of 70-31 Cupro-Nickel strip previously cold rolled 50% from material having a grain size of 0.070 mm.

→ the charts on these pages at small scale are intended to indicate range of properties and not to present exact data.

wide range of available manufactured forms

Revere is prepared to supply its products of copper, brass, bronze, nickel-silver and cupro-nickel alloys — also numerous special alloys—in most commercial forms. These forms—described in this section—include sheet, strip and roll . . . plate . . . rod and wire . . . shafting and piston rod . . . extruded shapes . . . pipe (SPS), copper water tube . . . seamless tubes . . . electric welded steel tube . . . lock-seam tube . . . condenser tube . . . die-pressed forgings . . . commutator segments.

Thus Revere products—in their wide selection of alloy and form —offer a wealth of efficient materials for redesigning present products and fashioning new ones.

Today Revere products—versatile, ductile, easily worked, corrosion-resistant, long-lived, readily finished and welded—are playing highly important roles in myriad applications: bolts and bellows . . . compacts and commutators . . . door chimes and dynamos . . . harmonicas and hinges . . . keys and kitchen utensils . . . radiators and radar . . . toys and telephones . . . watches and window frames.

sheet, strip, roll

Revere sheet, strip and roll is supplied in copper and in practically all the alloys listed in this catalog. Widths, gauges, lengths and tempers are available in a wide variety of combinations, depending upon the alloy and the required characteristics.

Special finishes may be available for some alloys and products. Very often products can be improved and costs reduced simply by using special finishes such as:

lacquered	bright dipped
nickel plated	tin-dip coated
tin plated	lead-dip coated
chromium plated	embossed
	crimped
lead plated	

polished (one or both sides)

Typical Revere sheet products for special uses include Engravers' Sheet Copper, Etching Brass, Fire Extinguisher Copper, Dairy Copper, Crimped Copper —and many alloy materials, in sheet form, for specialized applications.

plate

The term "plate" is used to designate flat metal in gauges ½ in. and thicker.

Revere has been producing nonferrous plate since Paul Revere rolled the copper plates from which the boilers of Robert Fulton's steamship "Claremont" were fashioned. Revere plates are dense in structure, free from blow holes and surface imperfections—characterized by flatness, accuracy of gauge, machinability and resistance to corrosion. They are used in marine and stationary condensers, heat exchangers, feed water heaters, oil coolers and similar equipment.

Extreme care is taken in the manufacture and finishing of Revere plate. Surfaces of all "cakes" are thoroughly inspected for cracks, inclusions and other defects. Subsequently, after milling and after the rolling operations, further rigid inspections are made.

Revere supplies plate, either hot or cold rolled, in squares, rectangles, circles, half-circles, segments or special patterns—up to 120 in. wide and a maximum finished weight of 11,000 lbs. Cold rolled plate can be furnished suitable for polishing.

Principal Revere plate alloys are: Muntz Metal, Roman Bronze, Naval Brass, Admiralty metal, Cupro-Nickel, Herculoy, Manganese Bronze and Copper.

rod, wire

Revere rod and wire are supplied in all standard shapes: round, square, hexagonal, rectangular, oval, half oval, etc. Standard shapes are generally available in copper and in most of the alloys described. Special shapes, depending upon the design of the section, are made of copper and a more limited number of the alloys. Certain alloys can be supplied with tinned or plated finish.

The basic operations for producing rod are either hot rolling or extruding. Finishing operations in the cold condition, such as drawing, are usually required. The physical properties of finished rod vary according to the alloy and process by which it is made. Generally, it is easier to develop higher physical properties in smaller sized rods. To insure uniform physical properties in the larger sizes, Revere rods are rolled from cast billets which are selected to give a reduction in cross sectional area of approximately 60% to 70%.

Wire and small size rod are ordinarily available in coils, but may be cut to straight, random or specified lengths. Special shapes may be obtained for the jewelry or novelty trade.

shafting, piston rod

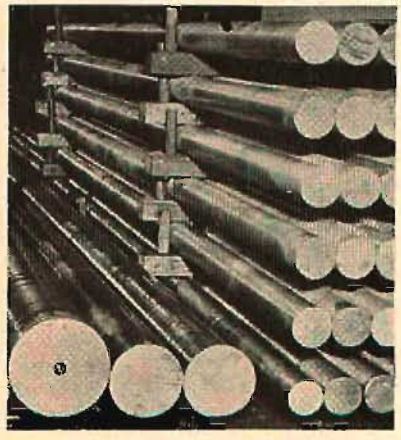
Revere Piston Rod is available in Roman Bronze and Naval Brass. The Naval Brass may be Commercial, Leaded or Free-cutting.

The common shafting mixtures are: Roman Bronze, Naval Brass, Herculoy, Aluminum Silicon Bronze, Manganese Bronze and Cupro-Nickel. Both Piston Rod and Shafting are fundamentally alike in that they have a uniform dense structure.

With piston rod, straightness must be combined with an extra smooth surface since the rod must pass through a stuffing box. This surface is obtained by means of a special grinding operation which eliminates any minute surface imperfections and assures great accuracy in dimension.

Shafting rod must be specially straightened to ensure that the rod will run true with no whip. Revere rod meets this requirement and is also provided with a good surface.

The maximum lengths furnished in both Shafting and Piston Rod vary with the diameter and alloy involved. Piston Rod is generally furnished in exact or multiple lengths.



special forms:

extruded shapes

Extruded shapes are made by forcing metal, previously heated to a semi-plastic state, through a die of the profile desired. The shaping of this die offers wide opportunity for developing unique shapes and contours. It is obvious that the forms so produced must be constant in cross section; that is, all grooves and slots must parallel the axis of extrusion and of the bar.

The extrusion process is extremely versatile. It produces cross sections of unusual form. These shapes when cut into short lengths can, in a great many cases, take the place of simple forgings, sand or die castings—at a considerable saving in tool, metal and finishing costs. As an important step in the complete fabricating of many products the extrusion process offers possibilities so numerous that they appear limited only by the ingenuity of the user.

speed production—lower costs

Extruded shapes are daily proving their worth by their ability to reduce manufacturing costs materially. Extruding is, in effect, pre-machining in our plant while the metal is in a plastic condition. This so-called pre-machining means fewer operations and less scrap in the customer's plant. Revere Extruded Shapes are well on their way to becoming your finished part—at a reduced cost.

readily machined

Revere Extruded Shapes are readily machined into a wide variety of products. Hinge butts are an excellent example of the facility with which Revere Extruded Shapes may be transformed into clean cut, finished products. With special holders or chucks, odd-shaped sections may be fed, in long lengths into turret lathes or screw machines where they are turned or drilled as readily as concentric rods. Due to their pre-shaped cross-section, they eliminate many subsequent milling or broaching operations. This results in savings in time, labor, and scrap.

Revere Extruded Shapes cut into short "slugs" are a means of cutting down the flash and excessive metal flow in the production of hot forged or hot pressed parts.

production limits

The overall size limit of Revere Extruded Shapes depends on the alloy and cross section; eight inches may be taken as a maximum when all conditions are favorable. The minimum thickness and the standard tolerances depend on the alloy, overall size, and intricacy of each particular section.

Alloys containing 56% to 60% copper are best suited to the extrusion process. As the copper content is increased or as other metals are added, the plasticity of the pre-heated billets is decreased. Extrusion, therefore, requires greater pressure and the shapes must be confined to relatively compact sections.

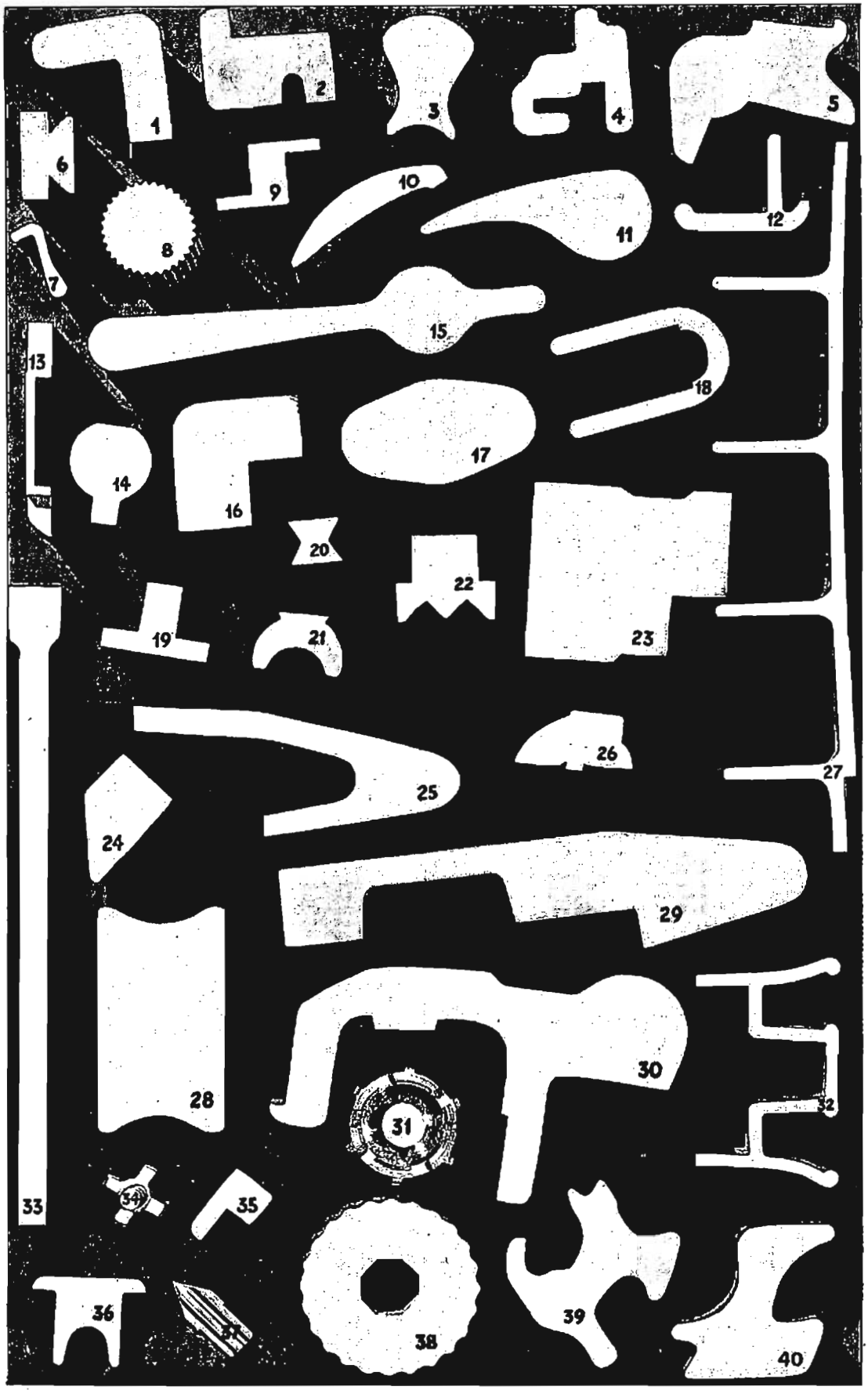
Revere Extruded Copper Shapes are used in the electrical and allied industries. Copper is extrudable only in slightly heavier sections than ordinary brass as copper requires higher temperatures and greater pressures for extrusion.

typical extrudable Revere alloys

alloy	uses, limitations
brass and bronze	
Architectural Bronze *(contains lead)*	architectural units: thresholds, window frames, pilasters, handrails, etc.
Brass, leaded or non-leaded *plain extruded* *extruded and drawn*	die pressed forgings stock for machining operations
Naval Brass *plain extruded* *extruded and drawn*	compact, simple shapes only; meets naval and government specifications
Free-cutting Rod *plain extruded* *extruded and drawn*	leaded rod particularly adaptable for industrial shapes made by manufacturers of screw machine products
Manganese Bronze *plain extruded* *extruded and drawn*	compact, simple shapes only
Michigan Cut-Fast Bronze *plain extruded* *extruded and drawn*	compact, simple shapes only
nickel	
Nickel Silver, 13% *plain extruded*	extrudable only in sections thicker than Architectural Bronze
copper	
Copper *plain extruded* *extruded and 1 draw* *extruded and 2 draws*	extrudable in simple, compact shapes with thick walls

After extrusion, Revere Extruded Shapes are carefully straightened and inspected. If increased tempers or closer tolerances are required, the metal is given subsequent draws.

Revere offers the cooperation of its engineering department in estimating cost of extruded shapes and in determining suitability of these shapes for various purposes.



at left

typical extruded shapes

section of:

1. copper relay or circuit breaker
2. special part
3. ornamental tray handle
4. typical brass unit
5. brass circuit breaker
6. embossing die body
7. finger in automatic gear shift mechanism
8. serrated brass rod for inserts in plastics
9. typical brass unit
10. aluminum belt moulding
11. special comb
12. furniture trim
13. lock bolt
14. lock tumbler
15. forging for faucet handle
16. elbow body
17. padlock body
18. wire connector part
19. typical tee
20. double dovetail for locking two parts
21. lock tumbler
22. air-tight gasket seal
23. heavy copper electrical unit
24. night latch
25. heavy copper electrical unit
26. loom part
27. vacuum filter in paper making machine
28. typical copper unit
29. heavy copper electrical unit
30. manganese bronze electrical unit
31. rod with six lugs machined in screw machine
32. typical parting strip for metal window
33. copper switch blade
34. extrusion (formerly made from casting)
35. typical brass unit
36. wire connector
37. needle valve
38. fluted knob base (hole is punched)
39. extruded and drawn naval brass unit
40. brass unit to replace die-cast part

Die-pressed Forgings

Revere Non-Ferrous Forgings can both improve your product, and cut your manufacturing costs. Product improvement is due to the fact that these forgings have increased strength-weight ratios, and hence weight reduction may be possible. Complicated parts previously built up of several pieces may be produced in a single piece, for greater strength, better appearance, and less cost. Revere Forgings are accurate in dimensions, so that machining is reduced considerably, and along with it, machine time, scrap and rejects. Thus these forgings can solve many production problems, open bottlenecks, and in addition reduce your costs.

Increased Strength • In non-ferrous die-pressed forging, the heated metal is placed between dies, and tremendous pressure forces the metal into the desired form. This produces a fine, close grain structure, greatly increasing tensile strength.

"Twice Wrought" • Revere Forgings are forged from Revere Extruded material. Thus the metal has attained the greatest possible density through being worked twice under the tremendous pressures employed in each operation. The result is the highest tensile strength, toughness and fatigue resistance possibly obtainable in the metal or alloy. A few alloys are heat-treatable if desired.

Better Appearance • Surfaces are good. Small design details such as trade-marks, model numbers and names can be held sharp and true.

Non-Porous • Being uniform in density and without blow-holes or similar defects, Revere Forgings are impervious to oils, other liquids, and gases. Hence they are widely used in chemical plants, oil lines, refrigeration and other gas apparatus.

Speedy Machining • The denseness and uniformity of the metal makes possible higher machining speeds. The absence of sand inclusions makes tools give longer runs before regrinding.

Plating • Any of the following finishes may be applied to Revere Copper and Copper Alloy Forgings with excellent results: pickling, bright dip, satin dip, bright polish, lead dip, cadmium plate, nickel plate, copper plate, chromium plate, silver plate, gold plate. For high-quality plating it is necessary to give the surface a preliminary polish, but the cost of this is low because of the relatively smooth surface of the forging.

Dimensions • Maximum and minimum dimensions and tolerances depend on the alloy and the design of the part. Revere can now produce larger forgings than ever before, up to 30" in the largest dimension in some cases.

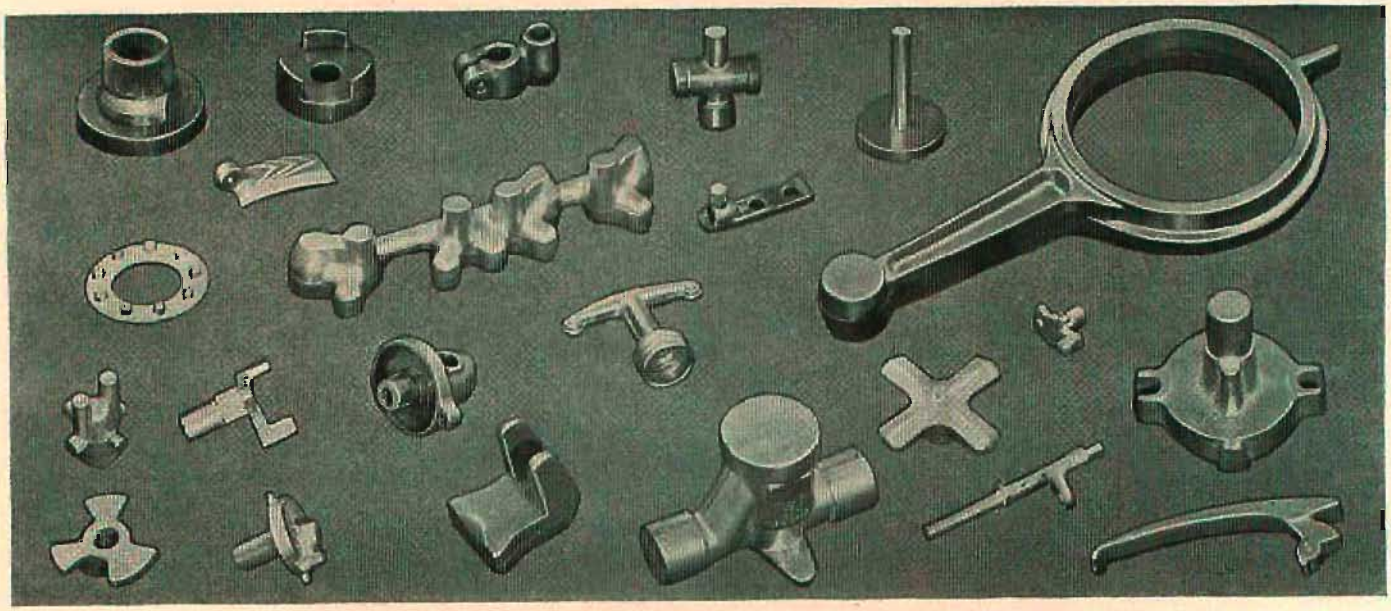
Long Experience • Revere, a pioneer in die-pressing hot non-ferrous metals into high-quality forgings, has since 1922 been developing machines and metals for this purpose. Today the Revere forging techniques produce exceptional results. Most of the alloys Revere forges are produced in Revere's own mills, under close laboratory control, and the forgings themselves are constantly inspected for size, strength and uniformity.

Custom-Made • Every Revere Forging necessarily is custom-made to your design. Revere Technical Advisors work closely with you to obtain the information needed by our die-makers, and to see you obtain the full benefits of the forging process.

Quantities • Large orders are not necessary. Dies for small lots may be made as cheaply in many cases as patterns for castings, and naturally subsequent orders still further reduce the cost.

Non-ferrous forgings are available in: Copper, Regular Brass, Naval Brass, Bronze, Magnesium Bronze, Aluminum Silicon Bronze, Herculoy, Nickel Silver, Aluminum Alloys, Magnesium Alloys.

Uses: For plumbing goods, hardware, pressure fittings, valves, engine parts, electrical equipment, automotive parts, welding nozzles, contacts, wing nuts, anchor bolts, bushings, refrigeration equipment, pump parts, housings, in general, highly stressed parts.



Switch Copper

Revere Switch Copper is produced by a special process from Electrolytic Copper and meets ASTM specifications for purity and electrical conductivity (98.0% min.). It offers important, new economies in the manufacture of switches knife-blade fuses, switchboards and similar products, requiring flat copper conductors with a minimum of contact losses.

This new form eliminates hand selection, sand blasting, wire brushing and other operations imperative with regular commercial bar. These economies more than offset the slight premium in price. With these expensive operations no longer required, it is only necessary to cut to length, drill and assemble.

Revere Switch Copper has a mirror-like finish. Its superior polish reduces losses at contacts. Edges are full rounded unless otherwise specified.

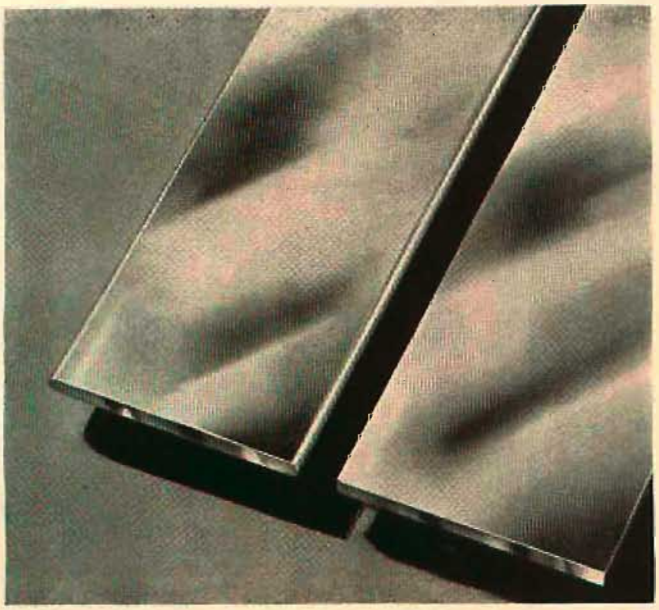
flatness tolerances • measured across bar width.

convexity	none
concavity, per side:	
widths up to 2 in.	.001 in. max
widths 2 in. and over	.002 in. max
camber (depth of lengthwise arc)	⅛ in. max in 8 ft

physical properties

tensile strength, psi	36,000 min.
elongation, % in 2 in.	15 min
Rockwell B hardness	35 to 65

Rockwell test is to be used for acceptance or rejection. If bending or other unusual requirements make customary temper unsuitable, special temper can be furnished upon request.



Free-cutting Copper Rod

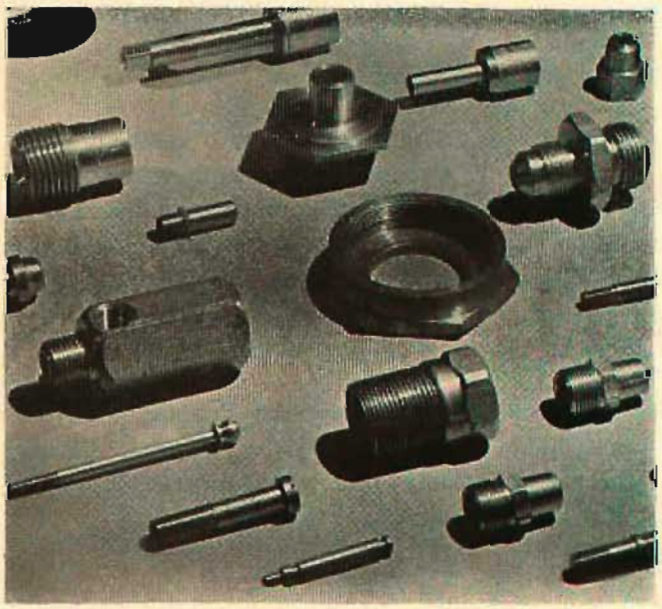
Revere Free-cutting Copper Rod is made of oxygen-free copper with a small amount of tellurium added. The tellurium content and special processing in the Revere mills combine to give remarkable qualities of machinability plus high electrical and heat conductivity. Thus this rod is ideal for many parts of electrical equipment, especially such items as contact pins, bolts and studs. It is also of prime interest to makers of vacuum tubes. Other important applications: welding tips, switch gear, relays, precision electrical equipment and parts that must be soft-soldered.

In machinability, this material is rated in excess of 70% of Free-cutting Brass. Close tolerances are easily held. Threads are sharp and clean. Machining speeds may be from two to five times those used with Electrolytic Copper. The metal, when supplied in the proper temper, can be either cold upset or hot forged.

Electrical conductivity of this material is 90% minimum. Heat conductivity is approximately the same as that of Electrolytic Copper. Available in round, square and hexagon, in sizes up to 2 inch. Also in special extruded shapes. This rod, however, does not make a vacuum tight seal with glass.

properties

density, lb per cu in.	0.323
melting point, °F	1980
coefficient thermal expansion, per °F, at 68° F	0.000010
electrical conductivity, % IACS (annealed)	90
thermal conductivity, Btu, per sq ft, per ft, per hr. per °F, at 68° F	205
tensile strength, psi (000 omitted)	32 to 50
elongation, % in 2 in.	10 to 20
Rockwell B hardness	20 to 45
F hardness (soft)	40 max



condenser tubes

The basic requirements of any condenser tube are corrosion resistance and erosion resistance. It is likewise important to consider the economic advantage of selecting the alloy most suited to meet operating conditions.

The life expectancy of an engineering tube depends upon the method of manufacture as well as the type of alloy used. Mechanical defects—surface imperfections, internal inclusions, gas cavities, contraction cavities—are possible focal points for future corrosion and zones of weakness that lead to failure.

In Revere Condenser Tubes—made by the extrusion process—there is complete assurance of *uniformly* sound metal. The extrusion method removes possibility of metallurgical flaws where they are most likely to occur: in the outer skin and inner core. For the outer skin and the inner core of the billet are *eliminated*.

The extruded tube, prior to any finishing operation, is a sound, clean, dense piece of metal with an excellent surface. In addition to the increase in quality made possible by the extrusion process, the secondary processing imparts to the finished tubes characteristics equally desirable.

extrusion process safeguards

• Use of solid cylindrical castings—decidedly less liable to internal casting defects than tubular castings.

• The solid casting is cut into short billets about ten inches in length and seven inches in diameter. After sawing and prior to extrusion, each cut surface is carefully inspected for possible flaws and casting defects.

• In solid cylindrical billet, internal casting defects (such as porosity) tend, if present, to concentrate in center of casting. In the extrusion process, the first operation consists of pushing out central plug of metal from the billet. Should the casting contain minor internal defects not detectable by visual inspection of the cut surfaces, the removal of this center would tend to reject such imperfections.

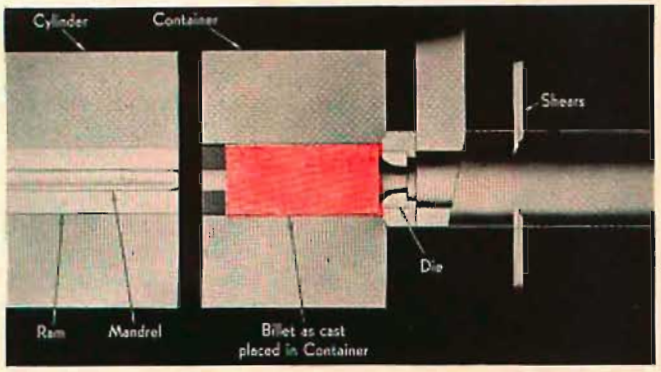
• A 1650-ton hydraulic press extrudes the tube from the billet, leaving behind a skin of metal, the "shell". In this shell, all subsurface imperfections or inclusions that may have been present in the original casting are retained.

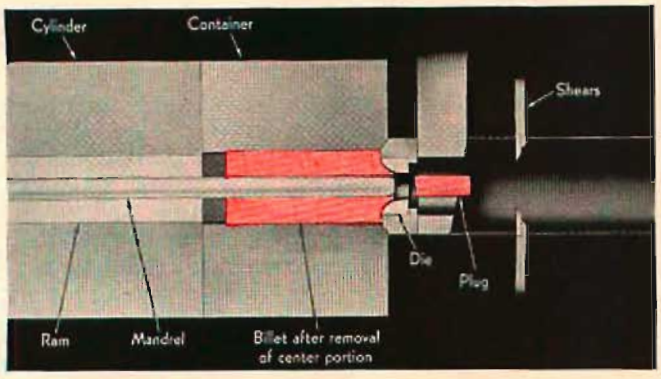
1 *Billet is placed in container.*

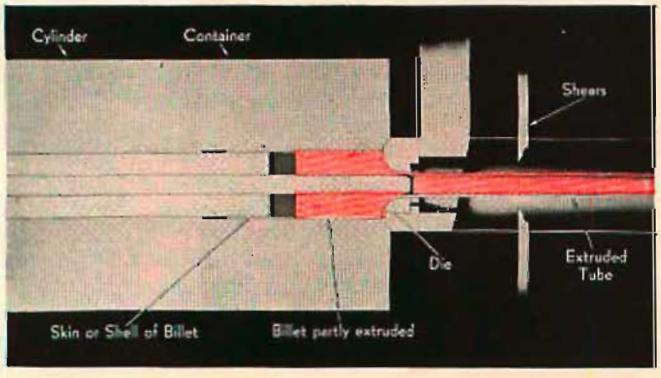
2 *Billet is held in place by ram while mandrel forces out center portion of billet—which contains possible casting defects.*

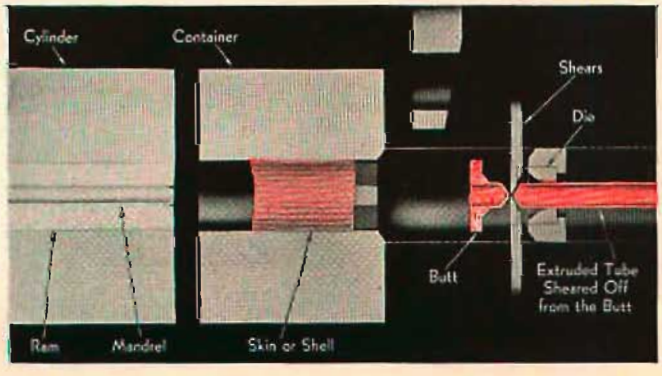
3 *Ram advances and forces metal in billet to flow between mandrel and die. The rough surface skin of billet is not pushed out and remains in containers.*

4 *Extrusion is completed: the remaining short butt end of the billet is sheared off from the extruded tube.*









Revere condenser tube alloys

Revere has developed several special alloy tubes to meet the severe operating conditions of modern use. No expense has been spared in equipping its mills to produce a quality tube of the highest attainable degree of mechanical perfection.

As each condenser and each heat exchanger presents an individual combination of conditions, no blanket recommendations are possible. Likewise it is not possible to develop a single alloy that can be recommended to give complete satisfaction under all operating conditions. Consequently Revere Condenser Tubes are fabricated in a number of highly successful alloys—each with its own characteristics and abilities to resist a definite combination of conditions that cause failure. Many related factors affect the life of the condenser tube and have an important bearing in determining the alloy which promises the longest possible life and the most satisfactory, trouble-free performance.

In selecting a condenser tube alloy, the following important factors should be considered: chemical composition of cooling water; conditions affecting condenser design and operation (such as velocity of cooling water in tubes); possibility of air entrainment; presence or absence of suspended solids; operating temperature.

To handle practically all conditions, or combination of conditions, Revere Condenser Tubes are available in eight alloys:

70-30 Cupro Nickel • Withstands highest operating temperatures and is not subject to dezincification. Forms tenacious protective surface film which resists impingement attack and erosion. Especially recommended for oil refining and marine service, also tropical waters.

80-20 Cupro Nickel • Similar to 70-30 in character, but less costly and somewhat less resistant to corrosive attack.

Revalon (aluminum brass) • The addition of aluminum makes this alloy superior for many applications — particularly where water velocities are high or where saline conditions exist. Revalon, carefully produced by the Revere extrusion process, forms a tenacious, self-healing film which renders the tube highly resistant to impingement attack.

Admiralty • Standard for many years. When properly fabricated by Revere extrusion process, Admiralty Metal tubes gives good service for long periods in a majority of applications. Arsenic is used as essential minor constituent for the purpose of inhibiting dezincification.

85-15 Brass (Red-Brass) • Widely used in many industries—due to its natural resistance to dezincification. Recommended for general piping purposes for excellent service at moderate cost.

Muntz Metal • Generally used in fresh water steam power plant installations where corrosive attack is mild.

Arsenical Copper • Arsenic content: 0.30%. Suitable for fresh water service where corrosive conditions are mild. Offers good thermal conductivity and improved resistance to special corrosive conditions. Popular in tanning and sugar industries.

Copper • The standard of the refrigeration industry and for transferring steam heat to water or air for heating purposes. It has excellent corrosion resistance to fresh water and highest thermal conductivity. It may be soldered and brazed into tube sheets with maximum facility.

Brass and Copper Pipe

Revere Red-Brass or Copper pipe is especially recommended for corrosive water conditions. In many cases, installations made 25 or more years ago have required neither attention nor repair. This pipe gives excellent service in many industrial applications; also for general plumbing and drainage lines.

Red-Brass (85% copper) • For extremely corrosive waters. Furnished in standard pipe sizes; for use with either threaded or silver-brazed fittings. Readily threaded, easily worked.

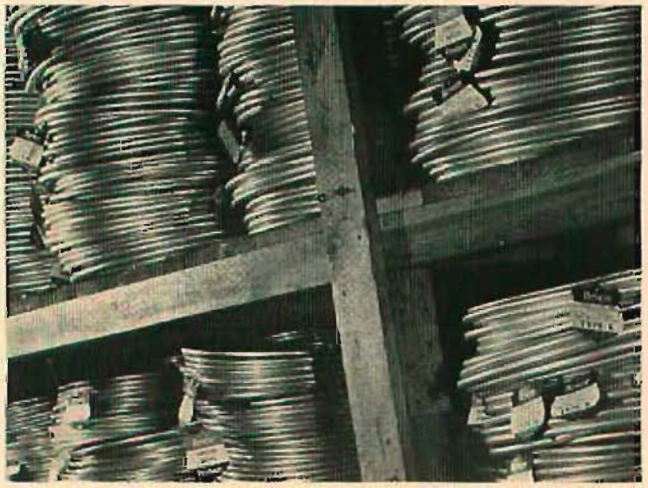
Copper (99.9% pure copper) • Being pure copper, it is used for industrial piping required to withstand severe service. Made in standard pipe sizes, in regular or extra strong wall thickness. Special sizes made to other dimensions and gauges.

Copper Water Tube

A cold-drawn, seamless tube: 99.9% pure deoxidized copper. Possesses gun-barrel finish inside, free from flaws and blemishes. Joints are made with soldered or compression fittings. *Type K:* for underground services, general plumbing and heating purposes; gas, steam, oil lines. *Type L:* for general plumbing and heating purposes. *Type M:* for general plumbing and heating purposes with soldered fittings—not for underground service. Types K and L, ⅜ to 12-in., nominal size; M, 2½ to 12-in.

DRYSEAL Copper Tube • A general utility tube in soft temper only, dehydrated and sealed . . . for refrigeration, automotive, air conditioning and air control systems . . . furnished regularly in 50-ft. coils in ⅛ to ¾-in. OD with .035-in. wall.

Other Copper Tube • *Type U:* approved by Underwriters for oil burner use. *Type B:* for industrial, marine, steam heating and other uses where OD of SPS pipe is necessary . . . can be used with SPS brazed fittings . . . unsuitable for threading.



Seamless Tube

Revere seamless tube, for cutting, forming and machining, is available in copper and the following alloys:

Red-Brass • Golden color when polished. Resistant to corrosive waters and atmospheres. Not free cutting. When soft, well adapted for bending, flaring, expanding. *Uses:* water lines, in cooling equipment, capillary and instrument tubes, electrical conduit, radiator cores.

70-30 Brass • Excellent ductility permits easy flaring, bending, expanding. Not free-cutting but readily machined when hard drawn. *Uses:* electrical fixtures, cylinder liners for pumps, air and hydraulic cylinders, plumbing goods, musical instruments, flashlight tubes.

Leaded Brass • For operations requiring good machinability. Lead content produces greatly improved cutting qualities. Physical properties similar to 70-30 Brass, but ductility is lower. Not suited for severe bending and forming. Limited cold-working readily performed. Specific recommendations difficult—due to variation in fabricating methods. Trial before selection should be made. *Uses:* screw machine parts, railroad equipment, small rifles, telephones, small valve parts, roller bearing cages, bushings, etc.

Muntz Metal • Higher zinc content than 70-30 Brass —consequently less ductility. Not adaptable to severe bending or cold-working. Excellent for hot-working.

Capillary • Made of 85-15 Red-Brass or Copper. Common ranges (0.26 to .040-in, ID) suitable for bulb and bellows assembly, measuring and control instruments, oil and gasoline gauges, recording thermometers. Meets rigid standards for metering devices. Inside diameter held to extremely close tolerances with uniform end-to-end bore. Chemically clean and free from all oxides, chips, grease, drawing compounds or other foreign matter. Substantially free from ordinary stress-corrosion cracking.

Welded Steel Tube

Revere Welded Steel Tube is produced by continuous electric resistance welding of flat rolled steel. Its use permits many products to be fabricated at reduced cost and with decided improvement in appearance.

The material selected is free from surface defects and possesses superior finish. Prior to forming and welding, the strip is carefully inspected to insure good surface for both inside and outside wall. Gauge tolerances are close on the steel strip; there is little variation in thickness across the width of the strip. The finished tube, therefore, has greater uniformity of wall thickness and concentricity of inside and outside diameters. This feature is especially important where practically perfect balance at high speeds must be combined with light weight, high strength and low cost.

High standards of concentricity also permit press or force fittings of associated parts without further machining. Revere Welded steel tube can be produced in special shapes at slight extra cost.

5 superiorities:

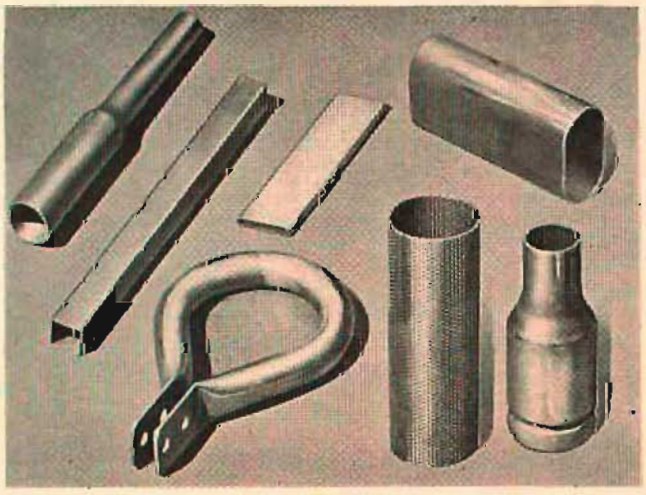
precision made • produced by continuous electric resistance welding of hot or cold rolled strip steel. Constant laboratory supervision maintains precision manufacture.

dependable • straight, accurate, true to gauge. Uniformity of wall thickness. Ideal for torque tubes, rotating parts, conveyor rolls, etc.

smooth, high quality finish • a controlled finish specially suitable for plating, lacquering, painting or other coating processes. Excellent surface for sliding parts.

special shapes • the use of special shapes often achieves improved product styling and reduces cost. Additional economies may be affected by fabricating tube to individual specifications.

economical • structural stability, uniform temper and correct analysis all make for economies. Costly operations in forming, machining and finishing are eliminated.

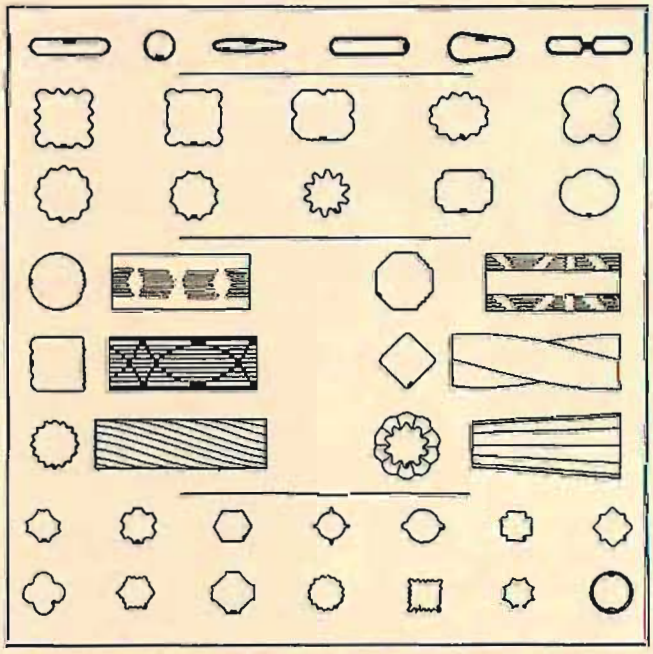


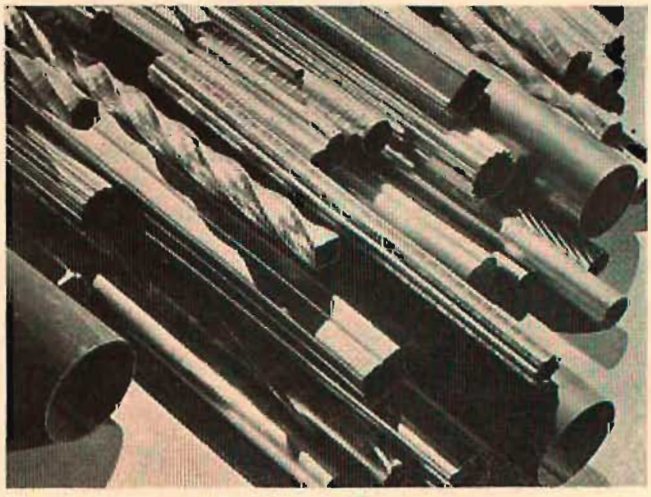
Lockseam Tube

For many years Revere has been a leading manufacturer of double Lockseam Tube, especially in the extensively used light gauges. The use of rolled strip in production of this tube assures uniform wall thickness, a particularly important feature in light gauges.

Lockseam Tube is used in many industries where low cost without sacrifice of quality is essential. Typical applications include radiator tubing, overflow tubing and exhaust pipe in the automotive field, handle bars in the casket industry, and fancy pattern tubes for lamps and fixtures.

Revere Lockseam Tube, plain or plated, is supplied in many Revere alloys; aluminum and zinc; also in tinned, plated or plain steel. Many shapes are available in several sizes and gauges.





methods of joining by welding

All of the common welding processes are employed in joining copper and the copper-base alloys as a group—but all methods are not practical for any one metal. The choice of joining method depends on a consideration of the corrosion problem, the size and design of the weldment, available welding and jigging equipment, and the characteristics of the various methods as they may have relation to the metallurgical and physical properties of the metal or alloy to be joined.

Often, where there is a choice between methods of joining, different fabricators may employ different methods to accomplish the same end. Similarly, one method may be employed by different fabricators with varying degrees of success.

non-pressure fusion methods

All three of the commonly employed manual methods—gas, metal arc and carbon arc are in general use. The gas method, because of the variety of flame atmospheres obtainable, finds widest use. Its disadvantages are cost, and in some cases, the warpage attendant with high conduction losses into the metal adjacent to the weld. Coated metal arc electrodes are not available in all the commonly employed welding rod alloys. In addition, the heat developed by the use of such electrodes (and such base metals as may be employed as electrodes) within the well defined optimum current range is often inadequate to compensate for conduction and other losses, and to obtain proper fusion. As a result, preheating is often necessary—especially when joining base metals with medium-to-high thermal conductivities.

The carbon arc method has the flexibility of the gas method in independence of heat and filler metal sources—but is superior to the gas method in maximum temperature and rate of heat development.

Automatic processes, such as carbon arc and submerged arc, are applicable in joining certain alloys. These processes produce economies and improvement of weld quality where repetitive work justifies their use.

pressure processes

Resistance welding (spot and seam) is practical on certain alloy compositions. The applicability is governed by the conductivity and surface preparation. In general, higher heats are employed for shorter periods of time, followed by a quicker, but lighter push-up than would be the case for the same thickness of steel. Equipment capacity and control are, therefore, important.

soldering and brazing processes

Soft solders and low-temperature brazing alloys are widely and successfully used in joining copper and the copper-base alloys. Gas torches are usually employed for manual brazing, but for production items dip-brazing in a salt bath permits greater control with fewer rejections.

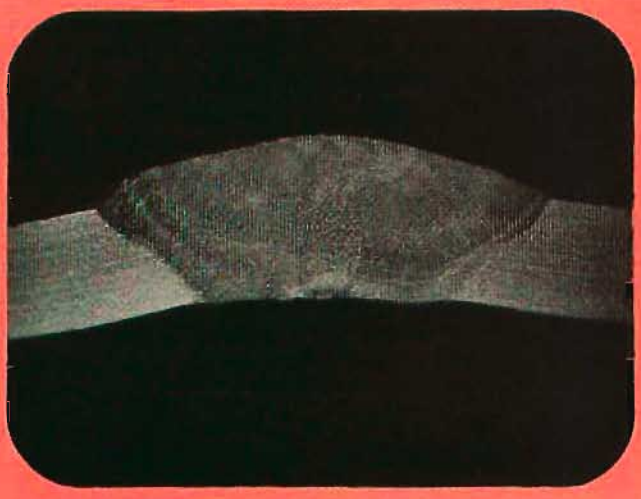
The "tempobrazing" process (resistance; Briggs U. S. patent 2,223,312) is used to braze relatively light gauges of cold rolled copper without material loss of metal temper. The induction and furnace brazing processes are not generally employed to join copper-base alloys, but instead, may employ these alloys to join other base metals.

Revere weldable alloys and the various types of Revere welding rod—with their pertinent characteristics, limitations, and the welding methods applicable to each—are discussed in this section:

welding of:

Backhand technique being employed to oxy-acetylene weld Deoxidized Copper in flat position.

Deoxidized Copper plate, ½-in. thick, oxy-acetylene welded with Revere Silicon Deoxidized Copper Welding Rod. Tensile strength of reduced section (as welded condition): 28,000 to 29,000 psi.



One-layer metal arc weld in cupro-nickel tube with ⅛-in. wall thickness: manually welded with coated electrode.

welding the cupro-nickels

The composition and physical characteristics of this class of alloys, especially the 70/30 composition, make them particularly well suited to joining by the various welding processes.

metal arc welding:

The availability of coated electrodes makes this the preferred method for manual welding. The technique, electrode diameter selections and joint designs employed in welding mild steel may be followed, with minor changes, in the use of these electrodes. Applicable specification requirements on welded joint properties can be consistently met only in the flat position.

submerged arc process:

Special granular material permits adaptation of equipment regularly employed for welding steel to the welding of cupro-nickels—when repetitive work justifies setting-up procedure details. A d-c source of current, however, is desirable.

oxy-acetylene method:

Shop use of this method is usually confined to welding of the very light gauges. Widest application is in field work where considerable position welding is involved in the installation or repair of piping. Special fluxes and a very slightly reducing flame are recommended to prevent any oxidation that might result from variations in the regulation of the flame atmosphere characteristics.

soldering and low-temperature brazing:

While all these processes are applicable, use has been generally confined to the lower flow point "silver brazing" alloys. Difficulties with intergranular penetration have been encountered on work-hardened material in which a stress gradient was set up on forming—when the Silver Copper eutectic composition alloy (72/28, flow point 1435°F) was used.

resistance welding:

The low conductivity of cupro-nickel makes it one of the most readily welded by this method.

welding Silicon Bronze (Herculoy)

Herculoy, Revere's Silicon Bronze, is one of the more weldable copper-base alloys. With a thermal conductivity roughly only 10% of that of copper and comparable to that of mild steel, high thermal losses by conduction are not encountered. Thus, all the common methods of welding find use:

carbon arc welding: Welds of code quality are readily produced manually in both sheet and plate. The high rate of heat input is attendant with rapid cooling of the weld through a "hot short" range which characterizes this group of alloys. As a result, no difficulties are encountered in the flat position welding of thicknesses up to 3/16 inch in one layer or thicknesses over 3/16 inch in layers of approximately ⅛ inch thick. Welding in other positions is possible, but not practical. Clamping fixtures in which a copper back-up bar is incorporated are recommended for the one-layer welds in light metal as a method of supporting and chilling the molten weld metal, and preserving the set-up alignment of metal edges.

With suitable heads and clamping fixtures, this method is also well adapted to automatic welding in the fabrication of range boilers and welded tubing.

gas welding: While more expensive, the oxy-acetylene method yields strong, sound welds of code quality. The lower rate of input is attendant with slower cooling. For this reason, use is usually limited to joints which may be run as "free seams". Stresses arising from contraction of the weld in cooling may cause cracking in the "hot short" range if the procedure details are not carefully controlled, or if provision cannot be made for contraction (as in "closed-structure" welds).

metal arc welding: Coated electrodes are available but the weld properties obtainable do not approach those yielded by either the carbon arc or gas methods. Metal transfer through the arc is globular with bare electrodes and maintenance of a comparatively large weld pool is necessary. For these reasons, the process is little used to weld Herculoy sheet and plate.

submerged arc welding: This process has not been widely employed to date. Preliminary reports, however, show promise.

resistance welding: Herculoy, because of its chemical and physical properties, is readily resistance welded in the lighter gauges. In addition to the equipment factors mentioned in the introduction, special cleaning—to remove an invisible refractory oxide film existing on metal cleaned by ordinary pickles—is necessary.

Orders for material intended for fabrication by resistance welding should be so marked. If manufacturing processes result in oxidation or other forms of contamination, it may be necessary to clean the metal by pickling or abrasive methods just prior to welding.

welding the coppers

choice of copper: Deoxidized Copper is to be recommended for all weldments where joining processes involving the temperature ranges of low temperature brazing and fusion welding are employed. The residual deoxidant in the base metal serves to protect the copper from oxidation; this oxidation might be followed by "embrittlement" if a flame containing hydrogen is employed to reheat the copper. While oxygen-free High Conductivity Copper does not originally contain any oxygen, it is not protected against extensive internal oxidation. Electrolytic Tough Pitch Copper contains oxygen which renders it readily susceptible to "embrittlement" by hydrogen-containing flame gases.

choice of method: The choice of method is dependent upon the type of joining medium employed; the latter is, in turn, dictated by the corrosion problem involved. The coppers with suitable joining mediums and methods are summarized briefly *in the order of preference from the joining standpoint:*

copper joining mediums and methods

plate metal	joining metal non-copper metals in color	joining method
Phosphor Deoxidized Copper (may be employed in the fabrication of unfired pressure vessels; case no. 934-special ruling; ASME unfired pressure vessel code)	Silicon Deoxidized Copper ■ Phosphor Deoxidized Copper Low ■ and high temperature brazing alloys	oxy-acetylene *(neutral flame)*
	Silicon Bronze ■ (Herculoy)	carbon arc
	Phosphor Bronze	carbon arc *(long arc)*
	Coated copper or coated alloy electrodes	metal arc
Oxygen-free High Conductivity Copper (or Phosphor Deoxidized High Conductivity Copper)	Low ■ and high temperature brazing alloys	oxy-acetylene *(neutral flame)*
	Silicon Bronze (Herculoy)	carbon arc
	Phosphor Bronze	carbon arc *(long arc)*
	Coated copper or coated alloy electrodes	metal arc
	Deoxidized Copper	oxy-acetylene *(neutral flame)*
Tough Pitch Copper	Low temperature brazing alloys ■	oxy-acetylene *(neutral flame)*
	Phosphor Bronze	carbon arc *(long arc)*
	High temperature brazing alloys	oxy-acetylene *(strongly oxidizing flame)*
	Coated copper or coated alloy electrodes	metal arc

■ preferred

fusion welding of copper

oxy-acetylene method: This method is rated first despite the higher costs involved: a copper filler metal may be used to produce an all-copper weldment to satisfy the most exacting corrosion-resisting requirements. Plate thicknesses of ¼ inch and over are preferably double welded in the vertical position by two operators utilizing a double-V or X-type joint. This procedure, which places emphasis on operator skill, most efficiently employs the heat of the two torches, the heat requirements for welding copper being substantially higher than that for the same thickness of steel. It also lends itself ideally to "hot peening" of short increments of the weld during execution; this is desirable on joints which cannot be run as "free seams" to offset the stresses developed as the result of shrinkage of the weld metal, and necessary when phosphor deoxidized filler rods are employed to develop the strength of soft copper plate.

Welds may also be executed by one operator assisted by a preheater where thicknesses of ¼-inch and over are involved. Such welding, which may be done either in the flat or near-vertical positions, usually requires chipping out and welding of the reverse side to insure complete penetration.

carbon arc method: the high rate of heat input possible with this method is utilized to establish a sharp temperature gradient which, in conjunction with high rates of progression (10 to 20 inches per minute) produces the minimum heat effect on the adjacent base metal. A copper backing bar is usually employed to support the overheated molten filler metal.

The carbon arc method is applicable to the welding of Tough Pitch Copper only with the fluid phosphor bronze filler rods which permit of the attainment of the higher rates of progression necessary to reduce the time-temperature heat effects on the oxygen-bearing base metal. Generally, the method may be employed for thicknesses which can be welded in one layer and without any preheat—approximately ⅜-inch maximum. Strengthwise, satisfactory joints are produced with phosphor bronze filler metal, but the ductility of the joint is erratic due to unsoundness.

Less fluid Herculoy welding rod may be employed at lower welding speeds and with a shorter arc to produce sound ductile welds in deoxidized copper. Layer welding is possible, as is preheating, but care has to be exercised to feed properly the shrink of craters when welding is stopped.

The carbon arc method with suitable heads may be automatically employed to weld copper. This method eliminates the variations in the correlation of procedure details (due to the human element). Wire feeding devices permit continuous welding. Elimination of "start and stop" points involved in manual welding precludes cracking at such points due to the "hot shortness" of the filler metals.

metal arc method: The current carrying capacity of the coated copper or bronze electrodes available are such that a preheat is necessary for the medium and heavier plate gauges. When employed for multi-layer welding, the preheat effect may be conserved by completing the weld in sections. Joints executed with the copper electrodes are satisfactory strengthwise—but ductility values, obtained in the usual manner on welds in the "as-welded" condition, do not approach those of gas welds either in value or consistency. The necessity of a preheat for certain thicknesses may result in "embrittlement" of the base metal adjacent to the weld.

low temperature brazing of copper

In addition to soldering, low-temperature brazing is widely and successfully employed both to join copper to copper, and copper to dissimilar metals. Preparation of the capillary type joints necessary for "silver brazing" may involve "thin edging" of light gauge sheet, or grinding and machining for plate edges and other type sections. Joint designs for brazing with brass or "bronze" alloys are often the same as those for fusion welded joints. Their higher melting points (1600° to 1650°F.) necessitates the use of an oxidizing oxy-acetylene flame when joining Tough Pitch Copper if "hydrogen embrittlement" is to be avoided with surety.

Cold rolled sheet copper may be "silverbrazed" by a resistance-pressure method, with little annealing effect. Strip brazing metal is automatically fed into a lap joint which is rapidly heated and chilled in a seam welder.

Salt baths which exclude the atmosphere are ideal sources of heat for the execution of the multiplicity of joints involved on production items such as unit heaters. Capillary joint conditions and preplaced rings of silver brazing type alloys permit execution of all the joints involved at one time—with the elimination of the defects attendant with manual one-at-a time execution.

welding the brasses

The addition of zinc to copper reduces the thermal conductivity and melting point of the resultant alloy, thereby facilitating welding. While there are a great number of modified alloy compositions to adapt them to special applications, selection for welding is usually confined to a few specific alloys; Muntz metal, Naval Brass, Manganese Bronze, and, in the tubing or special application field, Red Brass and Commercial Bronze. In general, leaded alloys are to be avoided because of the effect of lead on the quality of the weld and the properties of the base metal at elevated temperatures.

oxy-acetylene welding: This method permits use of standard brazing, or so-called "bronze welding" alloys with a modified nominal 60 copper, 40 zinc composition. It produces fusion welds in the alpha-beta brasses (essentially the same in composition as the base metal) and "brazes" or "bronze welds" in the alpha brasses of lower zinc content. Where similarity of analysis is essential in the alpha brasses, or in the color match of "architectural bronzes", strips of filler metal may be cut from the base metal.

carbon arc welding: This method may be employed for joints positioned for flat welding. Backing is necessary to support the filler metal which is very fluid under the intense heat of the arc. Zinc-free filler metals such as Herculoy (silicon bronze) and Phosphor Bronze (tin bronze), on which the arc is struck and maintained, are the most readily employed. Brass filler rods of the "low fuming" bronze welding alloy type have been employed with success. Voluminous fumes are, however, developed with this type rod; they must be exhausted to provide the operator with good vision and to protect his health.

Where corrosion is a factor, pre-heating is desirable to reduce temperature and resultant stress gradients; stress relieving may also be necessary. Pre-heating reduces the heat requirements of the arc; its use is desirable with both the less fluid silicon bronze and "low fuming" bronze filler rods.

metal arc method: The copper-zinc alloys may be welded with a number of the coated non-ferrous electrodes available: Aluminum Bronze and Phosphor Bronze. A preheat may be considered to be generally necessary—with the exact temperature depending upon the thermal conductivity and the mass of the base metal involved, as well as current carrying capacity and size of the electrode suitable for the application.

resistance welding: The brasses with more than 15 or 20% zinc are of sufficiently low conductivity that spot or seam welding of the lighter gauges is practical. Best results are obtained with the lower conductivity high zinc alloys, or special "silicon" brasses. As in the case of Herculoy (silicon bronze), cleaning is especially important.

soldering and low-temperature brazing: Both processes are widely employed and are applicable with the usual precautions to the type joints commonly employed for each. The stipulation with respect to lead content for fusion welding obviously does not apply to soft soldering.

welding phosphor bronze

The wrought "phosphor" or tin bronzes are often used in the cold worked condition for their resilient properties or spring qualities. These properties are destroyed or diminished in fusion welding and low temperature brazing. Both carbon and metal arc fusion methods have been employed successfully in the fabrication of process and other equipment.

bronze welding of ferrous metals

The use of copper and copper-base alloy welding rods in the welding of wrought copper and copper-base alloys is an important engineering application. Their use in reclaiming worn and broken machine parts, as well as in building up wear-resistant overlays on new parts of cast malleable and wrought irons, cast steel and cast bronzes constitute equally important applications.

Widest advantage is taken of the low melting points (1600-1650°F.) and properties of the brass or "bronze welding" alloys to repair, without fusion, broken cast and malleable iron machinery parts—in the automotive, marine, electrical, factory, farm, mine and railway fields. The high pre-heats and post-heating necessary in straight fusion welding of cast iron may be eliminated in some cases, and reduced in others. This, in conjunction with the low melting points of the bronze welding alloys, not only reduces labor and fuel costs, but the broken part is put back into productive use in considerably less time.

Special properties of certain alloys make them ideal for the compensation of wear on moving parts, and for building up overlays on surfaces subjected to sliding friction.

Other rods such as Herculoy find wide use in building up overlays by arc methods on cast and wrought steel parts (such as locomotive driving-boxes) where resistance to impact loading is important but the wear problem is not severe.

The phosphor bronzes are employed in both the repair and welded installation of bronze castings of the "Gun Metal" type.

Revere welding rods and their applications

rod	approx. melting point °F	approx. tensile strength ■ (000 omitted)	applications
Revere 456 (low-fuming)	1600	56 to 67	All-purpose gas "bronze welding" rod. Used in fabrication, salvage, repair fields; also for building up wear-resistant overlays.
Revere Bronze 380	1625	45 to 55	For gas welding of Naval Brass where similarity of analysis is essential.
Manganese Bronze 455	1600	50 to 58	Principally used for building up wear resistant overlays.
Herculoy 420	1866	50 to 58	For welding Herculoy by gas and arc methods; copper and brass by carbon arc method. Also for building up overlays by arc method.
Phosphor Bronze grade A grade D	1922 1830	42 to 44 50 to 51	For carbon arc welding of Electrolytic Copper, brass and Phosphor Bronze. For repair of gun metal castings.
Brass (Brazing Rod) 181	1634	40 to 50	Manual and controlled atmosphere furnace production brazing of steel assemblies.
Silicon De-oxidized Copper	1980	27 to 31 □	For oxy-acetylene welding of De-oxidized Copper.
Phosphor De-oxidized Copper	1980	18 to 32 •	For oxy-acetylene welding of De-oxidized Copper; higher strengths obtainable with "hot peening."
Electrolytic Copper	1980	——	For controlled atmosphere furnace brazing.

■ based on reduced section transverse tension coupons.
□ removed from welds in base metals of same type.
• in "as welded" condition.
peened while hot.

REVERE SHEET COPPER

Roofing Sheets, soft and cold rolled
- Plain
- Crimped

Lead Coated Sheets ("Leadtex"), soft and cold rolled

Sheets for Industrial Uses, all tempers
- Plain
- Polished
- Tinned

Fire Extinguisher Sheets (special temper and finish)
Dairy Sheets (specially rolled and heavily tinned)
Circles, Half Circles and Ovals
Segments and Patterns
Anodes, Flat and Oval, also Anode Hooks
Coppersmith Sheets

REVERE FLAT COPPER STRIPS

Exact or random lengths
Strips for Eaves Troughs or Gutters and Conductor Pipes or Downspouts
Lead Coated Strips ("Leadtex")
Strips for Industrial Uses, all tempers
- Plain
- Polished
- Tinned
- Embossed

REVERE COPPER IN ROLLS

Rolls for Roofing and Sheet Metal Work
Rolls for Industrial Uses
All tempers and finishes, for spinning, stamping, punching

REVERE BRASS ALLOYS

Sheets, Strips, Rolls, Circles, Half Circles, Ovals, Segments and Patterns
In all tempers and finishes

Gilding Bronze (95-5)	Cartridge Brass
Commercial Bronze (90-10)	Spinning Brass
Chain Bronze	2 and 1 Mixture
Rich Low Brass (85-15)	Yellow Brass (High)
Low Brass (80-20)	Drawing Brass
Spring Brass	Leaded High Brass
Admiralty Metal	Muntz Metal
Seventy-Thirty Brass	Naval Brass

REVERE BRONZE ALLOYS

Sheets, Strips, Rolls, Circles, Half Circles, Ovals, Segments and Patterns
In all tempers and finishes
- Silicon Bronze (Herculoy)
- Phosphor Bronze
- Manganese Bronze

July 1, 1946

REVERE NICKEL SILVER ALLOYS

Sheets, Strips, Rolls, Circles, Half Circles, Ovals, Segments and Patterns
In all tempers and finishes

Nickel Silver, 5%	Nickel Silver, 12%
Nickel Silver, 8%	Nickel Silver, 15%
Nickel Silver, 10%	Nickel Silver, 18%

REVERE CUPRO-NICKEL ALLOYS

Sheets, Strips, Rolls, Circles, Half Circles, Ovals, Segments and Patterns
In all tempers and finishes
- Cupro-Nickel, 20%
- Cupro-Nickel, 30%

REVERE SHEETS AND PLATES

Squares, Rectangles, Circles, Half Circles, Segments and Patterns
For Tanks, Condenser Plates (Heads), Structural, Architectural, Aircraft, Marine, and Transportation Applications

Muntz Metal	Cupro-Nickel
Naval Brass	Silicon Bronze (Herculoy)
Roman Bronze	Magnesium
Manganese Bronze	
Admiralty Metal	

REVERE ROD

Free-cutting Brass Rod, Free-cutting Copper Rod
Brass (not Free-Cutting), Red Brass, Commercial Bronze, Copper, Roman Bronze, Naval Brass, Muntz Metal, Manganese Bronze, Silicon Bronze (Herculoy), Aluminum-Silicon Bronze, Cupro-Nickel, Magnesium, Aluminum and Special Alloys.
Also furnished tinned, or plain extruded for forging

Round	Half Round
Hexagon	Oval
Pentagon	Half Oval
Octagon	Rectangular
Decagon	Triangular
Square	Irregular Shapes
Quarter Round	

REVERE SHAFTING AND PISTON RODS

Turned, Specially Straightened, also Polished

Roman Bronze	Silicon Bronze (Herculoy)
Naval Brass	Cupro-Nickel

REVERE WELDING RODS

Furnished Cut to Length or in Coils
Plain or tinned

Revere 456 (Low Fuming)	Phosphor Bronze, A and D Grades
Electrolytic Copper	Brass (Brazing Rod)
Revere Bronze 380	Silicon Deoxidized Copper
Manganese Bronze	Phosphor Deoxidized Copper
Herculoy (Silicon Bronze)	

g condensed list of Revere products

REVERE WIRE

Brass, Red-Brass, Commercial Bronze and Silicon Bronze (Herculoy)

In Coils or cut to length, tinned or plain

- Round
- Square
- Hexagon
- Octagon
- Half Round
- Half Oval
- Oval
- Quarter Round
- Flat Wire
- Triangular
- Special Shapes

REVERE DRAWN COPPER BAR

Also specially prepared Switch Copper for Bus Bars, Switches and General Electrical Purposes

In all tempers and finishes

- Rectangular
- Round
- Square
- Hexagon
- Pentagon
- Octagon
- Half Round
- Oval
- Triangular
- Quarter Round
- Special Shapes
- Hot Rolled Rods
- Commutator Bars
- Commutator Segments

REVERE EXTRUDED SHAPES

For Aircraft, Architectural, Industrial and Mechanical Uses

- Brass
- Architectural Bronze
- Nickel Silver
- Copper
- Special Alloys
- Magnesium
- Aluminum

REVERE SEAMLESS TUBES

Copper, Brass, Red-Brass, Commercial Bronze, Admiralty, Roman Bronze, Naval Brass, Silicon Bronze (Herculoy), Cupro-Nickel, Magnesium, Aluminum

In straight lengths or coils, in exact or random lengths, and all tempers

- Hexagon
- Octagon
- Lip-Tubes
- Reeded
- Fluted
- Rectangular
- Square
- Round O. D. with Special Shaped I. D.
- Special Shaped O. D. with Round I. D.
- Coppersmith Tubing
- Capillary Tubing
- Acid Dipped
- Special Annealed
- Sealed Ends
- Irregular Shapes
- Electro-Tin Plated
- Hot Dip Tinned
- Polished
- Plated (Nickel or Chromium)
- Telescoped
- Triangular
- Half Round
- Oval

REVERE COPPER REFRIGERATION TUBE

Dehydrated, Seamless, Dead Soft, Sealed Ends

In straight lengths or in long coils

Revere "Dryseal" Copper Tube
(in wrapped coils of 25 ft., 50 ft. and 100 ft.)

REVERE COPPER WATER TUBE

Plain or tinned

Type "K" } For underground ("K" only) and gen-
Type "L" } eral plumbing purposes and heating.
Type "M" } Also gas, steam and oil lines.
Type "U"—For oil burner use (manufacturing and installation).

REVERE PIPE (Standard Pipe Size)

Red-Brass, Copper, Magnesium, Aluminum

Tinned, polished, plated (nickel or chromium)

Regular Pipe Sizes (standard weight)
Extra Strong Pipe Sizes (extra heavy weight)

REVERE CONDENSER TUBES

Outside diameters from ⅝" to 2" with wall thicknesses from No. 8 to No. 19 Stubs' Gauge

- Cupro-Nickel, 30%
- Cupro-Nickel, 20%
- Aluminum Brass (Revalon)
- Admiralty
- Arsenical Brass
- Arsenical Copper
- Red-Brass
- "70 and 30" Brass
- "85 and 15" Brass
- "2 and 1" Brass
- Muntz Metal
- Silicon Bronze (Herculoy)

LOCKSEAM TUBES AND ROLLED SHAPES

Revere Lockseam Tubes—All sizes and shapes for Aircraft Tubes, Automotive Radiators, Radiator Overflow Tubes, Lamp and Fixture Tubes, Casket and Grave Vault Handle Tubes and other General Uses

Plain or tinned

- Copper
- Brass
- Bronze
- Nickel Silver
- Cupro-Nickel
- Zinc
- Aluminum

DIE-PRESSED FORGINGS

Furnished plain also partially or completely machined as desired

- Brass
- Bronze
- Copper
- Nickel Silver
- Cupro-Nickel
- Silicon Bronze (Herculoy)
- Aluminum Bronze
- Aluminum-Silicon Bronze
- Magnesium
- Aluminum

REVERE SPECIAL PRODUCTS

- Printing Rollers
- Singe Plates
- Soldering Coppers
- Special Stampings
- Copper Clad Stainless Steel Cooking Utensils
- Eyelets and Screw Shells
- Terrazzo Strip
- Welded Steel Tube
- Giftware and Novelties

July 1, 1946

Revere Technical Advisory Service

Revere maintains its Technical Advisory Service to cooperate with product designers, engineers and others in developing the use of copper and copper-base alloys. This Service is staffed by competent men thoroughly conversant with copper and copper-base alloys and modern fabricating techniques. Their function is to work directly with designer and manufacturer; to study problems relating to metals; and to submit to Revere Research Department major problems requiring scientific study. These advisors deal with concrete problems of immediate concern. For specific information about this Service, contact the Revere office in your locality.

Revere Copper and Brass Incorporated

Executive Offices: 230 Park Avenue, New York 17, N. Y.

division offices and mills:	telephone	teletype
Baltimore Division P.O. box 2075, 1301 Wicomico Street, Baltimore 3, Md.	*Gilmore 0222*	*BA 164*
Michigan Division 5851 West Jefferson Avenue, Detroit 9, Mich.	*Vinewood 1-7350*	*DE 237*
Chicago Manufacturing Division 2200 North Natchez Avenue, Chicago 35, Ill.	*Merrimac 2600*	*CG 957*
Rome Division Rome, N. Y.	*Rome 2000*	*ROME NY 447*
Magnesium-Aluminum Division P.O. box 2075, 1301 Wicomico Street, Baltimore 3, Md.	*Gilmore 0222*	*BA 164*
Dallas Division 2200 North Natchez Avenue, Chicago 35, Ill.	*Merrimac 2600*	*CG 957*
New Bedford Division 24 North Front Street, New Bedford, Mass.	*New Bedford 8-5601*	*NB 87*
Rome Manufacturing Company Division Rome, N. Y.	*Rome 2800*	*ROME NY 449*

district sales offices:		
Atlanta 3, Ga., Rhodes-Haverty Building	*Main 2142*	*AT 96*
Boston 10, Mass., 140 Federal Street	*Hubbard 7190*	
Buffalo, 7, N. Y., 1807 Elmwood Avenue	*Delaware 7616*	
Cincinnati 2, Ohio, Carew Tower	*Main 0130*	*CI 171*
Cleveland 15, Ohio, Midland Building	*Cherry 3930*	*CV 572*
Dallas 1, Texas, Tower Petroleum Building	*Central 8681*	*DL 88*
Dayton 2, Ohio, Mutual Home Building	*Hemlock 3271 & 8921*	*DY 107*
Grand Rapids 2, Mich., Keeler Building	*Grand Rapids 9-3301*	*GR 376*
Hartford 3, Conn., 410 Asylum Street	*Hartford 7-8174*	*HF 87*
Houston 2, Texas, Mellie Esperson Building	*Fairfax 7932*	
Indianapolis 4, Ind., Circle Tower	*Riley 1322*	
Los Angeles 15, Calif., 714 West Olympic Boulevard	*Richmond 9314*	
Milwaukee 2, Wis., 628 East Wisconsin Avenue	*Marquette 1440*	*MI 292*
Minneapolis 2 Minn., Metropolitan Building	*Atlantic 3285*	
New York 17, N. Y., New York Central Bldg., 75 East 45th St.	*Murray Hill 9-6800*	*NY 1-1222*
Philadelphia 3, Pa., Sixteen Sixteen Walnut St. Bldg.	*Pennypacker 5-6133*	*PH 206*
Pittsburgh 19, Pa., Gulf Building	*Court 4342*	*PG 572*
Providence 3, R. I., Industrial Trust Building	*Gaspee 8110*	
St. Louis 1, Mo., Telephone Bldg., 1010 Pine Street	*Garfield 4416*	*SL 191*
San Francisco 4, Calif., Calif., Russ Building	*Sutter 0282*	
Seattle 1, Wash., 1331 Third Avenue	*Main 8372*	

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