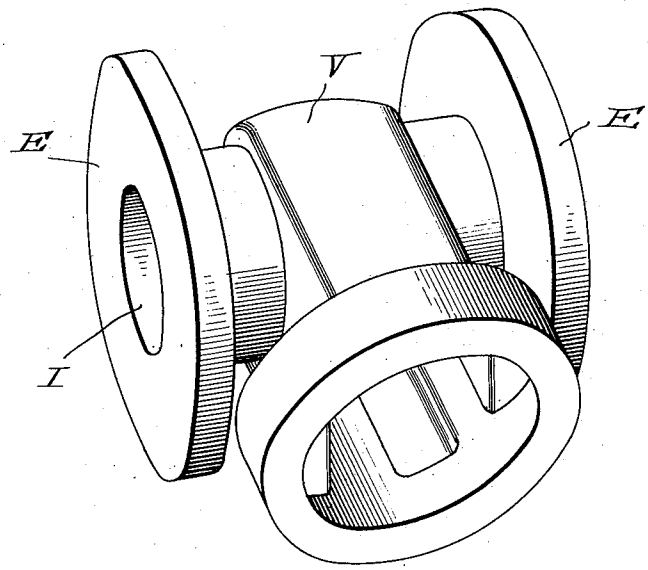
Sept. 24, 1940. T. E. KIHLGREN 2,215,905

PRESSURE CASTING

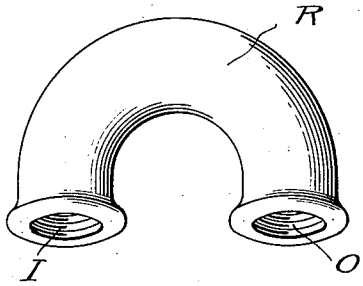
Filed March 29, 1939

Fig. 1.



30% CUPRO-NICKEL CONTAINING
0.5% SILICON AND 1% MANGANESE

Fig. 2.



30% CUPRO-NICKEL CONTAINING
0.5% SILICON AND 1% MANGANESE

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Patented Sept. 24, 1940 2,215,905

UNITED STATES PATENT OFFICE

2,215,905

PRESSURE CASTING

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Application March 29, 1939, Serial No. 264,694

10 Claims. (Cl. 75—159)

The present invention relates to the production of pressure tight castings made of copper-nickel casting alloys, and a method of producing the same.

It is well known that 70/30 cooper-nickel alloys, referred to herein as cupro-nickel, are particularly well adapted for use where excellent resistance to corrosion is required. The alloys possess anti-fouling properties and practical freedom from pitting and water-line attack which make them particularly suitable for use in applications where resistance to sea water corrosion and the like is required. Outstanding applications of the alloys in wrought form include marine condenser tubes, salt water lines such as fire lines and sanitary lines, condensers in oil refineries and in power stations at seaboard locations, sheathing for lifeboats, fuel lines and tanks aboard ship, and the like. In conjunction with the increased use of wrought cupro-nickel has come the need for cast fittings such as couplings, T's, L's, pump bodies, valve bodies, etc., all of which must be sound and pressure tight. The casting of plain cupro-nickel presented numerous difficulties. Its castability left much to be desired and it was practically impossible to consistently obtain sound castings possessing high physical properties such as are required in pressure castings. Oftentimes, the castings also tended to be brittle. This defect was particularly noticeable when the castings were being machined as evidenced by the breaking down of sharp corners. The casting of cupro-nickel containing 30% nickel, i. e., between 25% and 35% nickel, was a serious problem which was further complicated by the inherent difficulty of casting such alloys compared to alloys containing only small amounts of nickel, for example, 15% nickel. Copper-nickel alloys containing large amounts of nickel, for example, 30% nickel, are more difficult to cast sound than low nickel alloys probably because of their higher melting point combined with the greater tendency of the higher nickel content alloys to absorb gases in melting. While a melting procedure might be quite satisfactory for 15% cupro-nickel, the same procedure might be quite useless for 30% cupro-nickel in consistently obtaining the desired soundness, pressure tightness and properties.

Although many attempts were made to remedy the aforementioned shortcomings, none, as far as I am aware, was entirely successful when carried into practice commercially and the consistency with which pressure tight castings were obtained left much to be desired.

I have discovered that the prior art shortcomings can be avoided and that new and unexpected results can be obtained by incorporating controlled and balanced amounts of manganese and silicon in cupro-nickel pressure castings.

I have found that 30% cupro-nickels containing controlled and balanced amounts of manganese and silicon possess improved castability and soundness combined with improved physical properties, particularly when the melting and casting procedure is carried out in the improved manner described hereinafter.

It is an object of the present invention to provide improved cupro-nickel castings which are consistently sound and which possess improved physical properties.

It is another object of the present invention to provide improved cupro-nickel pressure castings containing controlled and balanced amounts of silicon and manganese and characterized by consistent soundness of metal combined with improved physical properties.

It is also an object of the present invention to provide improved cupro-nickel pressure castings containing balanced proportions of silicon and manganese and characterized by high fluidity when being cast.

It is a further object of the present invention to provide improved cupro-nickel pressure castings which are consistently free from blow holes, cavities, dross, and the like and free from hot cracking tendencies.

The invention contemplates an improved process for consistently producing sound cupro-nickel castings free from blow holes, cavities, entrapped dross, and the like.

The invention also contemplates improved high nickel cupro-nickel alloy castings containing controlled and balanced amounts of silicon and manganese and characterized by improved castability and by improved physical properties as cast.

The invention further contemplates an improved high nickel cupro-nickel which possesses special casting characteristics rendering the consistent production of sound pressure tight castings relatively simple in the foundry and possessing good physical properties and corrosion resistance comparable to that of wrought 30% cupro-nickel.

Other objects and advantages of the present invention will become apparent to those skilled in the art from the following description taken in conjunction with the accompanying drawing, in which:

Fig. 1 is a perspective view of a cast flanged

gate valve body embodying the present invention; and

Fig. 2 is a perspective view of a cast return bend likewise embodying the present invention.

Broadly stated, the invention provides improved pressure tight castings made of cupro-nickel alloys containing controlled and balanced amounts of silicon and manganese. The cupro-nickels contemplated by the present invention consistently possess improved fluidity and castability combined with excellent physical properties. Satisfactory cupro-nickel castings, particularly pressure castings, are obtained when the composition is maintained within the approximate ranges given in Table I.

Table I

Element	Percentage
Nickel	25 to 35
Silicon	0.1 to 1
Manganese	0.4 to 1.25
Copper	Balance

When the silicon content is between about 0.1% and about 0.25% it is further desirable that the minimum manganese content be set at about four times as much as the silicon content, particularly for the lower silicon contents, e. g., 0.1% or 0.15% silicon. As the silicon content increases over about 0.25% the manganese content should exceed about 0.8% but the ratio of manganese to silicon need no longer be maintained. When the high corrosion resistance and other properties of 30% wrought cupro-nickel are desired, it is preferred to maintain the nickel content above about 28.5%.

I have found that when silicon is added without manganese to simple 30% cupro-nickel casting alloys it has several undesirable effects. The metal becomes sluggish to pour, a tough film or envelope forming about the stream of metal. The occurrence of patches of smooth gray films in the solidified metal indicates the entrapping of this surface film in the casting. Hydraulic tests on pressure castings treated with silicon but free from manganese often leaked at such low pressures as 40 pounds per square inch. The fractures were also found to be very coarse, indicating that silicon also has a pronounced undesirable grain coarsening effect. It has also been discovered that silicon imparts marked hot cracking tendencies. Hot cracking tendencies are of particular importance in cored castings and when present produce undesirable cracking during cooling after casting. Hot cracking appears to be a phenomenon involving the shrinkage of the metal as it cools coupled with the lack of resistance to rupture at elevated temperatures from the stresses produced thereby. If soundness is defined to imply freedom from both porosity and entrapped oxides, dross, slag or dirt, it may be stated that silicon alone is entirely unsatisfactory in 30% cupro-nickels for use in pressure castings. A simple 30% cupro-nickel casting alloy with manganese, for exampe 1% manganese, and without silicon is also rather sluggish and in addition, possesses the mediocre mechanical properties of the plain 30% cupro-nickel as cast.

The co-presence of balanced and controlled proportions of silicon and manganese within the ranges specified herein neutralizes or counteracts the defects of silicon alone or manganese alone and imparts excellent fluidity to the melt to yield consistently satisfactory sound pressure castings with clean fine grained fractures. The thin but tough film and general sluggishness of melts containing only silicon is entirely absent in the manganese plus silicon melts. The simultaneous presence of controlled and balanced amounts of silicon and manganese also neutralizes to a considerable extent the grain coarsening tendency of silicon alone. The excellent fluidity of the molten metal greatly diminishes the occurrence of dross inclusions in the casting and contributes to obtaining pressure tightness. Hot cracking tendencies are also greatly decreased and the probability of a continuous channel through which leakage from the interior to the exterior of the casting can take place is also decreased. The proper balance of silicon and manganese reduces brittleness and permits machining with substantially no detrimental breakdown of sharp corners. The co-presence of manganese and silicon thus neutralizes or counteracts most of the disadvantages accompanying the addition of silicon alone to pressure castings while maintaining and supplementing the effectiveness of silicon in reducing gross porosity and imparting improved properties to 30% cupro-nickel casting alloys for use in pressure castings.

For general applicability and when good castability and soundness of pressure castings are the primary consideration excellent results are obtained when the silicon content is within the range of about 0.2% to about 0.5%, for example about 0.3%, and the manganese content is within the range of about 0.8% to about 1.2%, for example about 1%. Within these ranges satisfactory high physical properties are obtained combined with excellent castability and pressure tightness. However, when good castability, pressure tightness and soundness combined with higher physical properties are desired in the high nickel cupro-nickel pressure castings, the silicon and manganese contents should be held within the approximate ranges given in Table II. Cupro-nickel castings containing high silicon, particularly large amounts such as 0.75% or more, tend to be susceptible to hot cracking. When balanced amounts of silicon and manganese are co-present as specified in Table II, the pressure castings are markedly free from hot cracking tendencies. The high silicon contents in conjunction with the balanced amounts of manganese produce high physical properties, for example tensile strength exceeding about 50,000 pounds per square inch, without the disadvantage or shortcoming of hot cracking. The present invention thus provides high nickel cupro-nickel pressure castings containing high silicon and characterized by freedom from hot cracking combined with soundness and high physical properties.

Table II

Element	Percentage
Silicon	0.5 to 1
Manganese	0.8 to 1.2

The 25% to 35% cupro-nickel pressure castings may contain, in addition to balanced amounts of silicon and manganese, small amounts of various other elements such as iron, zinc, carbon, titanium, aluminum, tin, magnesium, phosphorus, sulfur, and the like. Iron in amounts up to 1.5% has very little effect on the castability of a manganese and silicon-containing

melt. It has a slight tendency to neutralize the undesirable effects of silicon. As far as castability is concerned, iron is quite unnecessary and its chief benefit would be its effect on the physical properties. In general, iron up to 1.5% at least, increases the elastic properties rather sharply and the tensile strength moderately without loss of ductility. Iron is, however, somewhat objectionable from a corrosion angle, particularly in marine applications, and for this reason should be kept as low as is practical. Preferably the iron content should not exceed 1.5% and 1% represents a safer maximum value when high corrosion resistance is desired. Cupro-nickels containing 30% nickel and about 5% to about 9% iron with balanced amounts of silicon and manganese have exhibited excellent castability and high physical properties but such alloys do not provide suitable corrosion resistance to sea water and tend to produce coarse fractures. The addition of zinc in amounts up to 1.5% has slight effect on either the castability or physical properties. It may be useful as a scavenger but is far from necessary. Zinc tends to decrease the corrosion resistance and should be kept below 1%, preferably below 0.5%, where this property is important. Lead, even in small amounts, such as 0.25%, is extremely deleterious in cupro-nickel pressure castings containing silicon and manganese, producing leakers and excessively coarse structures and making the metal hot short. Lead also effectively destroys the ductility and toughness of the pressure castings and tends to produce hot cracking. In view of its detrimental effect, lead should preferably be maintained below about 0.05% maximum. Carbon appears to exert a mild strengthening effect, increasing the elastic and strength properties and very slightly diminishing the ductility. It is preferred to maintain the carbon content below about 0.15% to about 0.2%. Low carbon melts of cupro-nickel containing balanced proportions of silicon and manganese give somewhat sounder, uniform pressure castings having fine grained fractures. Small amounts of titanium, say less than 0.2%, while not necessary, may have beneficial effect in the presence of carbon. In carbon-free pressure castings titanium tends to produce dirty fractures and entrapped dross. The physical properties also tend to be somewhat inferior to similar castings free from titanium. Aluminum imparts strong film forming tendencies with the resulting strong possibility of entrapping some of the film in the pressure casting and, from a castability viewpoint, should be kept low. Aluminum does increase the elastic and tensile properties sharply. It is preferred to maintain the aluminum content below about 0.05% maximum. Small amounts of tin, say up to 1%, may be quite satisfactory in corrosive media and would appear to have slight beneficial effects on physical properties and castability. The addition of small amounts of magnesium, say about 0.025%, appears useful in counteracting small amounts of sulfur, for example up to 0.02%. It is to be understood that when I say "balance substantially copper" or "balance substantially all copper" in the description and claims I do not mean to exclude minor elements such as iron, magnesium, phosphorus, carbon, sulfur and other elements mentioned herein or such as occur in cupro-nickel alloys as a result of commercial production methods.

In carrying the present invention into practice excellent cupro-nickel pressure castings are obtained when a silicon content of about 0.25% to about 1% is used in the presence of about 1% manganese. Typical examples of the compositions of cupro-nickel pressure castings made in accordance with the present invention are given in Table III.

Table III

Alloy No.	Nickel	Copper	Silicon	Manganese	Other elements
	Percent	*Percent*	*Percent*	*Percent*	
1	30	Balance	0.1	0.4	
2	30	do	0.15	0.6	
3	30	do	0.2	0.8	
4	30	do	0.25	1.0	
5	30	do	0.5	1.0	
6	30	do	0.75	1.0	
7	30	do	1.0	1.0	
8	30	do	0.3	1.2	
9	30	do	0.5	0.8	
10	30	do	0.5	1.0	1.0% Fe.
11	30.2	do	0.5	1.1	1.03% Fe.
12	30.0	do	0.39	1.03	1.1% Fe.
13	30.2	do	0.5	1.1	1.3% Fe
14	30	do	0.25	1.0	1.5% Fe.
15	30	do	0.5	1.0	1.5% Fe.
16	30	do	0.75	1.0	1.5% Fe.
17	30	do	1.0	1.0	1.5% Fe.
18	30	do	0.5	1.0	1.5% Fe, 0.14% C.
19	26	do	1.0	0.8	1.5% Fe.

Pressure castings having the composition contemplated by the present invention are very sound and possess high physical properties, particularly with increased silicon contents in the presence of manganese. The properties fall within the approximate ranges given in Table IV. An addition of about 1.5% iron raises the strength properties about 5,000 to 8,000 pounds per square inch with substantially little change in elongation.

Table IV

Tensile strength, p. s. i.	40,000 to 90,000
Yield point (0.5% ext.) p. s. i.	15,000 to 70,000
Elongation (in 2 inches) percent	40 to 5
Brinell hardness	50 to 190

p. s. i.=Pounds per square inch.

Illustrative examples of the physical properties possessed by pressure castings made in accordance with the present invention are given in Table V.

Table V

Alloy No.	T. S.	Y. P.	El.	B. H. N.
2	42.0	15.0	40	50
4	45.0	16.0	37	86
5	55.0	25.0	35	102
6	68.0	43.0	21	
7	85.0	68.0	7.5	188
11	63.2	31.5	39.0	
12	60.0	28.3	37.0	
13	66.5	35.0	35.0	
14	50.0	20.0	40	100
15	60.0	32.0	39	117
16	75.0	50.0	27	
17	92.0	74.0	5	200
19	94.0	77.7	6	196

T. S.=Tensile strength in thousand pounds per square inch.
Y. P.=Yield point (0.5% extension under load) thousand pounds per square inch.
El.=Per cent elongation in 2 inches.
B. H. N.=Brinell hardness number (1000 kg. load).

In addition to possessing high physical properties, pressure castings made in accordance with the present invention are very sound and pressure tight. For example, cast bushings made of alloys 4 to 7 and 14 to 17, inclusive, were tested at 1250 pounds per square inch fluid pressure and were found to be pressure tight, i. e., the castings did not leak. The metal was of excellent quality, clean, sound and of uniform color. A slight in-

crease in grain size was noted as the silicon content approached the upper limit. The necessity for the co-presence of manganese and silicon in proper proportions is very important as will be observed from Table VI which gives the casting properties of 30% cupro-nickels containing silicon or manganese alone and manganese plus silicon both in improper proportions and in accordance with the present invention.

Table VI

Silicon	Manganese	Castability, soundness, grain size, etc.
Percent	*Percent*	
0.22	0	Sluggish, castings leaked (1), fractures coarse and drossy.
0.37	0	Sluggish, fractures coarse, discolored, slightly dirty.
0.62	0	Do.
0	1	Sluggish, difficult to cast, mediocre properties.
0.05	0.75	Do.
0.05	2.2	Sluggish, difficult to cast, pressure tight (2).
0.35	0.20	Very sluggish, castings leaked (1), fractures drossy and coarse.
0.05	0.20	Castings gassy and unsound.
0.10	0.40	Fairly satisfactory, sound (3), fine grained, safety margin slim.
0.15	0.60	Satisfactory, sound, pressure tight (2), fine grained.
0.20	0.80	Excellent, clean, sound, pressure tight (2).
0.50	0.80	Satisfactory, sound.
0.25	1.0	Good fluidity, clean, fine grained, pressure tight (4).
0.50	1.0	Good fluidity, clean, moderate grain size, pressure tight (4).
1.0	1.0	Good fluidity, clean, slightly coarser grain size than with 0.5% silicon, pressure tight (2).

(1) Leaked at 40 pounds per square inch fluid pressure.
(2) Tested at 1,000 pounds per square inch fluid pressure.
(3) Tested at 1,000, 1,250, and 1,750 p. s. i. fluid pressure.
(4) Tested at 1,250 p. s. i. fluid pressure.

It has been noted hereinbefore that manganese has a pronounced effect in minimizing hot cracking at relatively high silicon levels. This hot cracking tendency is most pronounced when the silicon content exceeds about 0.75%. The effect of managense on 30% cupro-nickel (containing about 1.5% iron) is clearly demonstrated in Table VII and Table VIII which gives the physical properties of some of the pressure castings.

Table VII

Alloy No.	Silicon	Manganese	Hot cracking
	Percent	*Percent*	
22	0.75	0	Severe.
23	0.88	0.02	Do.
24*	0.81	0.02	Do.
25	0.75	1.0	None.
26*	0.75	1.1	Do.
27**	0.79	1.2	Do.

*Also contained 0.01% magnesium.
**Also contained 0.02% magnesium.

Table VIII

Alloy No.	T. S.*	Y. P.*	El.*
22	35.8	------	Nil
23	16.0	------	Nil
25	77.7	58.7	9.5
26	82.5	58.5	13.0
27	90.3	64.4	14.3

*See footnote to Table V for key.

The hot cracking effects are readily observed in the physical properties, tensile fractures and on simple "ring" tests. "Ring" tests on unmachined cast bars still untested can be simply carried out by dropping the bars on a hard surface and noting the metallic "ring" or resonance. Cupro-nickels which contain hot cracks give no metallic "ring." It will be noted that none of the castings containing proper proportions of manganese and silicon showed signs of hot cracking, while all of the substantially manganese-free bars showed severe cracking, being "dead" on the ring test. The hot cracked bars possessed a coarse radial fracture whereas the bars containing proper silicon and manganese were fine grained. The undesirable coarsening effect obtained in silicon-containing cupro-nickels substantially free from manganese contributes greatly to increased hot cracking tendencies.

The pressure castings of the present invention may be produced in the usual or conventional manner but it is preferred to carry out the procedure in the manner described hereinafter. In accordance with the preferred procedure, nickel and copper (and iron if it is to be present) are charged into any suitable furnace, for example a crucible or electric furnace. Oil fired crucible furnaces insure more rapid melting and greater ease in meeting the pouring temperature requirements than coke-fired crucible furnaces. Induction and indirect-arc rocking type furnaces, as well as direct-arc furnaces may also be used, a suitable slag being desirable in the latter instance. The nickel and copper may be added in any desired form but it is preferred to use virgin metal at least in part. Up to 50% of clean remelt scrap may be included in the charge satisfactorily and under some conditions even higher proportions may be used. For normal operation an average figure of about 40% scrap in the charge should be satisfactory. Remelt scrap when used is preferably added after the oxidizing treatment described hereinafter. The use of nickel-copper alloy shot and the like, for example 50/50 or 2/1 nickel copper shot, may be found desirable under certain conditions, e. g., where the melting equipment is somewhat inadequate with respect to temperatures attainable. It is highly important that the charge be substantially lead-free as this element is decidedly detrimental in pressure castings. The charge is melted down, preferably using slightly oxidizing conditions, for example an oxidizing flame. The molten bath is then deliberately oxidized in any suitable manner, preferably by adding nickel oxide, for example about 1.5 ounces of black nickel oxide per hundred pounds of molten metal, or copper oxide, for example about 3 to about 3.5 ounces per hundred pounds of molten metal, or both. The oxide addition may be placed in paper bags and dropped into the melt and stirred in vigorously. The addition of oxides and the like may not be necessary when sufficient oxidation is provided by the oxidizing conditions during melting and/or the oxidation provided by the introduction of scrap into the charge through attached scale, surface oxides, and the like. The introduction of about 0.02% to about 0.1% oxygen, preferably about 0.1%, is sufficient to produce the desired results. Larger oxygen contents may be used but are not necessary and will subsequently require the use of larger quantities of deoxidizers in order that the final manganese and silicon contents be within the desired ranges. When the charge is melted under slightly oxidizing conditions an addition of about 0.2% to about 0.4% cuprous oxide, or an equivalent amount of nickel sesqui-oxide, for example about 0.08% to about 0.15%, or an equivalent amount of both, will usually give the desired oxygen content and produce the desired results. Any remelt scrap,

for example remelt risers and gates, are preferably added after the oxidation treatment. Shortly before tapping the heat (or pulling the crucible), for example about three to about five minutes before pulling the crucible, manganese and silicon are added, preferably simultaneously. The amount of manganese and silicon added should include the amounts desired in the final alloy plus an additional amount to take care of deoxidation. For an oxygen content of about 0.1% the additional silicon and manganese required is about 0.05% silicon and about 0.2% manganese. The manganese and silicon are preferably added as 97% manganese metal (low carbon) and refined silicon (97% silicon) but may be added in any other suitable elemental or alloyed form. When remelt scrap is included in the charge, allowance should be made for the manganese and silicon introduced with the scrap. The amounts of manganese and silicon added may be satisfactorily based on the amount of new metal in the charge when the remelt scrap contains substantially the desired silicon and manganese content, for example 0.50% silicon and 1% manganese. Immediately on tapping the heat or pulling the crucible an addition of about 0.025% magnesium is a useful precaution to take care of any sulfur pick-up which may have occurred in the melt down. The temperature of the molten metal is properly adjusted during the final stages in the furnace and the melt poured at temperatures within the range of about 2500° F. to about 2700° F. into well vented molds, generously gated and fed. Castings of moderate to heavy sections should be poured on the low side, for example at or below about 2575° F., and light castings should approach 2650° F. Too high a pouring temperature tends to produce leaky castings. Thus, a casting poured at 2750° F. leaked under hydraulic test while other castings poured at 2635° F. and at 2585° F. were pressure tight, the best casting being obtained at the latter temperature. It is essential that 30% cupro-nickel pressure castings be generously fed. The molding sands should be refractory and of fairly high permeability, e. g., 40 to 60 (A. F. A.), with a moisture content of about 4.5 to 5.5%. Excellent results are obtained with synthetic sands of about 80 permeability and about 5% moisture. Low permeability sand, e. g., about 16 or 25, should be avoided. Pressure castings produced in accordance with the procedure set forth have consistently possessed excellent casting properties and soundness combined with high physical properties.

The present invention provides improved pressure castings which consistently possess excellent castability and soundness combined with improved physical properties. Pressure castings include hollow bodies, e. g., bodies cast about a core, which in use are required to be pressure tight. Typical examples include valve bodies, pump bodies, and cast fittings, for example, L's, T's, Y's, crosses, unions, couplings, bushings, return bends, headers, nozzles, nipples, plugs, reducers, laterals, and the like.

As an illustrative example of the foregoing, Fig. 1 shows a cast flanged gate valve body of a well known type formed of a 30% cupro-nickel alloy containing about 0.5% silicon and about 1% manganese. The hollow valve body V is provided with flanged ends E about the inlet opening I and the outlet opening (not shown) directly opposite thereto. Fig. 2 shows a cast return bend of a well known type formed of a similar cupro-nickel alloy and illustrative of the cast fittings contemplated by the present invention. The return bend R is provided with inlet opening I and an outlet opening O connected to each other to permit the flow of liquids therethrough. The foregoing illustrative examples are characterized by soundness of metal and pressure tightness upon hydraulic testing and in use combined with high physical properties.

Although the present invention has been described in conjunction with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Such variations and modifications are considered to be within the purview and scope of the appended claims.

I claim:

1. As an article of manufacture, a pressure casting made of an alloy comprising about 25% to about 35% nickel, about 0.2% to about 0.5% silicon, about 0.8% to about 1.2% manganese, and the balance substantially all copper, said pressure casting being characterized by soundness of metal and pressure tightness combined with improved physical properties.

2. As an article of manufacture, a pressure casting made of a cupro-nickel alloy comprising about 25% to about 35% nickel, about 0.5% to about 1% silicon, about 0.8% to about 1.2% manganese and the balance substantially all copper, said pressure casting being characterized by soundness of metal and pressure tightness combined with high physical properties, including a tensile strength exceeding about 50,000 pounds per square inch, and improved freedom from hot cracking tendencies.

3. As an article of manufacture, a pressure casting made of an alloy comprising about 28.5% to about 35% nickel, about 0.1% to about 1% silicon, about 0.4% to about 1.25% manganese, the manganese content in said alloy being at least about four times the silicon content for small silicon contents up to about 0.2% silicon and being at least about 0.8% for higher silicon contents, and the balance substantially all copper, said pressure casting being characterized by soundness of metal and pressure tightness combined with improved physical properties and corrosion resistance approaching that of wrought 30% cupro-nickel.

4. As an article of manufacture, a pressure casting made of an alloy comprising about 25% to about 35% nickel, about 0.1% to about 1% silicon, about 0.4% to about 1.25% manganese, the manganese content in said alloy being at least about four times the silicon content for small silicon contents up to about 0.2% silicon and being at least about 0.8% for higher silicon contents, and the balance substantially all copper, said pressure casting being characterized by soundness of metal and pressure tightness combined with improved physical properties.

5. As an article of manufacture, a pressure casting made of an alloy comprising about 25% to about 35% nickel, about 0.1% to about 1% silicon, about 0.4% to about 1.25% manganese, the manganese content in said alloy being at least about four times the silicon content for small silicon contents up to about 0.2% silicon and being at least about 0.8% for higher silicon contents, and the balance substantially all copper, said pressure casting being characterized by im-

proved soundness of metal resulting from a melting and casting procedure involving an oxidation treatment.

6. A process for consistently producing pressure tight castings made of cupro-nickel alloys containing about 25% to about 35% nickel, about 0.1% to about 1% silicon, and about 0.4% to about 1.25% manganese, the manganese content being at least four times the silicon content for small silicon contents up to about 0.2% and being at least about 0.8% for higher silicon contents, which comprises establishing a molten bath containing nickel and copper, subjecting said bath to an oxidation treatment sufficient to produce a molten bath containing at least about 0.02% to about 0.1% oxygen, adding silicon and manganese shortly before pouring in amounts sufficient to leave a residual silicon content in the metal of about 0.1% to about 1% and a residual manganese content therein of about 0.4% to about 1.25%, said manganese content being at least about four times the silicon content for small silicon contents up to about 0.2%, and being at least about 0.8% for higher silicon contents and casting the thus-treated molten metal containing about 25% to about 35% nickel and the balance, aside from said silicon and manganese contents, substantially all copper at temperatures within the range of about 2500° F. to about 2700° F. whereby pressure-tight cupro-nickel castings are consistently obtained substantially free from unsoundness and characterized by improved physical properties.

7. A process for consistently producing pressure tight castings made of cupro-nickel alloys containing about 25% to about 35% nickel, about 0.1% to about 1% silicon, and about 0.4% to about 1.25% manganese, the manganese content being at least four times the silicon content for small silicon contents up to about 0.2% and being at least about 0.8% for higher silicon contents, which comprises establishing a molten bath containing nickel and copper, subjecting said bath to an oxidation treatment, adding silicon and manganese shortly before pouring in amounts sufficient to leave a residual silicon content in the metal of about 0.1% to about 1% and a residual manganese content therein of about 0.4% to about 1.25%, said manganese content being at least about four times the silicon content for small silicon contents up to about 0.2% and being at least about 0.8% for higher silicon contents, and casting the thus-treated molten metal containing about 25% to about 35% nickel and the balance, aside from said silicon and manganese contents, substantially all copper at temperatures within the range of about 2500° F. to about 2700° F. whereby pressure-tight cupro-nickel castings are consistently obtained substantially free from unsoundness and characterized by improved physical properties.

8. A cupro-nickel casting containing balanced proportions of silicon and manganese and comprising about 25% to about 35% nickel, about 0.2% to about 0.5% silicon, about 0.8% to about 1.2% manganese, and the balance substantially all copper, said casting being characterized by improved soundness of metal combined with high physical properties.

9. A cupro-nickel casting containing balanced proportions of silicon and manganese and comprising about 25% to about 35% nickel, about 0.5% to about 1% silicon, about 0.8% to about 1.2% manganese, and the balance substantially all copper, said casting being characterized by improved soundness of metal combined with high physical properties, including a tensile strength exceeding about 50,000 pounds per square inch.

10. A cupro-nickel casting containing balanced proportions of silicon and manganese and comprising about 25% to about 35% nickel, about 0.1% to about 1% silicon, about 0.4% to about 1.25% manganese, the manganese content in said alloy being at least about four times the silicon content for small silicon contents up to about 0.2% silicon and being at least about 0.8% for higher silicon contents, and the balance substantially all copper, said casting being characterized by improved soundness of metal combined with high physical properties.

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