UNITED STATES PATENT OFFICE.

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ALLOY.

1,115,239. Specification of Letters Patent. Patented Oct. 27, 1914.

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To all whom it may concern:

Be it known that I, SAMUEL W. PARR, a citizen of the United States, residing at Urbana, in the county of Champaign and State of Illinois, have made new and useful Improvements in Alloys, of which the following (being in part a continuation of my application Serial No. 705,386, filed June 24, 1912) is a specification.

Bomb calorimeters as ordinarly used are constructed of steel with the inner faces lined with platinum or with gold plated copper to resist the corrosive action of the nitric acid liberated in the calorimeter when in use. Such constructions have the disadvantage of high cost, and also the disadvantage that moisture may work in under the lining and subsequently impair the accuracy of the heat determination. Also platinum linings as thus used within a calorimeter are easily damaged and are otherwise objectionable, as is well known.

As the result of extended experiment and investigation I have discovered a new alloy which is so resistant to the corrosive action of the moist oxygen or of ordinary acids such as nitric acid that it can be used within the calorimeter and exposed directly to the action of the calorimeter charge. The alloy is so resistant that it may be used for valve seats, and similar parts of the apparatus where the wear and exposure are extreme, without appreciable corrosion or deterioration even after long continued use. This alloy is also adapted for use in the construction of chemical vessels, and as electric resistance wire and as a substitute for platinum and other expensive materials and in the form of a wire or sheet metal suitably shaped and worked, may be used in a great variety of ways, where its special characteristics make it of special value in the technical arts. In general this new alloy comprises nickel as its basis, together with a certain amount of chromium or of molybdenum or of both and a somewhat smaller quantity of copper. The chromium accentuates the acid resisting properties of the nickel, and tends to increase the melting temperature and also leads to brittleness. The copper on the other hand tends to lower the melting point, but it cannot be used except in moderate quantity without lowering the resistance to corrosion. I have found that there is also advantage in having tungsten present and while its presence may not be necessary, yet it tends toward easy casting and also strengthens the acid resisting properties of the alloy. Molybdenum may be used in place of tungsten to a very considerable extent with some resultant advantages. Tungsten is much like chromium in promoting resistance to acid attack, but it is quite in contrast with chromium in that it permits easy casting and reduces shrinkage. Aluminum and manganese in small quantities can also be used to advantage being added after the mass is fluid and when it is about in condition for pouring. Aluminum lowers the melting point of the alloy somewhat and besides being a good deoxidizer, it accentuates the resistance to both nitric and sulfuric acid. Manganese serves much as aluminum. Titanium and boron in fractional percentages may also be used.

I have found that the relative proportion of the elements above named may be varied through relatively wide limits and still yield an alloy having, in the main, the mechanical strength and toughness and the acid resisting characteristics of metal suitable for use in calorimeters, and as electrical resistances, and in the arts generally. I have found that the following composition by weight gives good results: 63 parts nickel, 5 parts copper, 15 parts chromium, 10 parts of molybdenum-chromium alloy in equal percentages, 2 parts tungsten, $1\frac{1}{2}$ parts aluminum, $1\frac{1}{2}$ parts manganese-titanium alloy compounded in the proportions of 70 parts manganese to 30 parts titanium, 1 part manganese-boron alloy compounded in the proportion 70 parts manganese to 30 parts boron, 1 part copper-silicon alloy compounded in the proportions 80 parts copper to 20 parts silicon, $\frac{1}{2}$ part boron suboxid (approximately $B_{15}O$). As to variations from the above proportions, I have found that the nickel content may vary between 55 and 65 per cent., and the copper between 5 and 11 per cent. As to the members of the chromium group, viz., chromium, molybdenum and tungsten, these metals are to some extent interchangeable, but preferably should total in the neighborhood of 27 per cent. Molybdenum, in its behavior, seems more pronounced than tungsten in promoting resistivity to acid, and may vary from

5 to 8 per cent. The chromium content may vary between 15 and 21 per cent., the tungsten between about 2 and 3 per cent., and the aluminum between ½ and 1½ per cent. The manganese and titanium may be omitted altogether, although I regard them as substantial aids in casting and as desirable deoxidizers. The boron and boron suboxid can also be omitted, their principal functions being that of a flux and degasifier, but if any boron remains behind in the alloy it offers no disadvantage and may even present some advantages. Silicon also may be omitted.

In practice I prefer to melt together in about the proportion above indicated, the nickel, chromium, molybdenum-chromium alloy, copper and tungsten, and then after the melt is fluid, I add the aluminum, manganese-titanium alloy, manganese-boron alloy and copper-silicon alloy in about the proportions stated, these additions serving to remove gases and increase the fluidity of the melt and otherwise assisting in bringing the material into better physical and chemical condition for pouring. Finally I add the one-half per cent. suboxid and this acts to eliminate absorbed gases and to deoxidize the other metals.

In some melts I have omitted both the copper-silicon alloy and the boron flux and still obtained a satisfactory product and I am aware that the manganese may be omitted and that various changes may be made in the admixtures of the aluminum, manganese, titanium and boron, without greatly influencing the final result, though the proportions above indicated are, at the present time, considered by me as most satisfactory in obtaining uniformly good results. The boron, besides acting as a deoxidizer, appears to act as a mixer. Some carbon may be present to the extent of $\frac{1}{10}$ of 1 per cent., and my research indicates that the carbon has some virtue in helping to resist the solvent action of acid. Some iron may be present without harm, say $\frac{1}{10}$ of 1 per cent.

The best melting and casting temperature for the alloy here disclosed, in its various modifications, is in the neighborhood of 1300 degrees centigrade with 1500 degrees centigrade as the upper limit.

The alloy may be cast in iron molds not heated, or in sand, and when thus made has a tensile strength of about 55,000 to 60,000 pounds per square inch. The cast material can be rolled and drawn into wire and can be spun and mechanically worked according to well known metal working methods. With drawn wire, the tensile strength is much greater than that given for the cast material, being in the neighborhood of 124,000 pounds per square inch in some cases. The relatively great strength and toughness of the alloy even in cast condition is of importance when the material is used in the construction of calorimeters, because the pressure developed within the calorimeters may be as high as 1000 pounds per square inch, even under normal conditions. Also this great strength and toughness makes the alloy suited for use in the mechanical arts, in a great many ways, where a corrosion resistant material is essential. The electrical resistance of the alloy is high, being in the neighborhood of fifty times that of copper. The melting point is in the neighborhood of 1200 to 1300 degrees centigrade.

The material, either in cast, rolled or drawn condition is non-oxidizable in the ordinary sense. Corrosion, if it occurs at all, at atmospheric temperature and pressure, when 100 square centimeters area is subjected for twenty-four hours to four times normal HNO_3 or H_2SO_4, or mixtures of these acids, is so slight as to be substantially within the experimental error of weighing, even though the balance used may show changes of one-tenth of a milligram. Samples of about ten square centimeter area have been exposed for as long as ten days to 25 per cent. nitric acid with no loss in weight which could be detected by the most accurate weighing. With other samples under the same conditions, there was a loss of .002 milligrams per 100 square centimeters per hour in 25 per cent. nitric acid and for practical purposes this may be regarded as no corrosion.

The alloy is equally insoluble in 25 per cent. H_2SO_4 or in a 25 per cent. mixture of two parts sulfuric acid to one part nitric acid. In 25 per cent. hydrochloric acid, the corrosion is possibly twice as high as in nitric (for such samples as show any corrosion in nitric), and consequently even with hydrochloric, the material may be said to be non-corrosive.

As the result of the continued use of the alloy here disclosed, for exposed surfaces in a bomb calorimeter of the construction disclosed in my application above identified, where the alloy is directly in contact with the hot gases, it may be said that the total corrosion within the bomb, under the extreme temperatures and pressures there encountered, need not exceed $\frac{1}{10}$ of a milligram for each heat, and such a slight corrosion, assuming that it might take place, would introduce a variable of not more than 1 part in 10,000 which of course, is well within the experimental accuracy of methods for using bomb calorimeters.

In addition to the use of this alloy for bomb calorimeters and for valves, valve seats and exposed portions of chemical vessels, it has a wide range of uses in the electrical and mechanical arts where its special characteristics of relative great strength and

toughness, high electrical resistance and more particularly its resistance to oxidation or corrosion, can be made use of.

I claim:

1. A non-oxidizing alloy having a composition of about 63 parts nickel, 5 parts copper, 20 parts chromium, 5 parts molybdenum, and 2 parts tungsten.

2. A non-oxidizing alloy consisting of approximately 63 parts nickel, 5 parts copper, 20 parts chromium, 5 parts molybdenum, 2 parts tungsten, and a small percentage of deoxidizing material substantially as described.

3. A non-oxidizing alloy having a composition of about 63 parts nickel, 5 parts copper and 27 parts metal of the chromium group, with a small percentage of deoxidizing metal, substantially as described.

4. An alloy having a composition of about 63% nickel, 5% copper, 20% chromium, 5% molybdenum, 2% tungsten and less than 2% each of aluminum, manganese and boron, substantially as described.

5. An alloy of about the composition 63% nickel, 5% copper, and 27% metal of the chromium group, said alloy being characterized by a high electrical resistance, by high resistance to corrosion, and by a tensile strength for unworked metal in the neighborhood of 60,000 pounds per square inch, substantially as described.

In testimony whereof I affix my signature, in presence of two witnesses.

SAMUEL W. PARR.

Witnesses:
F. W. BECK,
F. H. BARTON.