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HEAT-RESISTING ALLOY AND STRUCTURE, ETC.

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To all whom it may concern:

Be it known that I, NOAK VICTOR HYBINETTE, a citizen of the United States, residing temporarily at Wilmington, in the county of New Castle, State of Delaware, have invented certain new and useful Improvements in Heat-Resisting Alloys and Structures, Etc.; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to heat-resisting alloys and structures adapted to withstand high temperatures for long periods of time.

The heat-resisting alloys that have been used prior to my invention were mainly used at temperature of 900° C. to 1000° C. and for the most part intermittently at these temperatures, and the alloys and products available on the market were not reliable for use over long periods of time or were not uniformly reliable, one casting, for example, standing up satisfactorily in use, whereas others would fail without any visible reason. These previously known alloys and structures were, moreover, expensive to produce and were available only at a correspondingly high cost. These previously known alloys contained, for example, about 60% nickel, 12 to 20% of chromium, and the rest iron; while certain alloys contained iron and chromium without nickel.

In comparative tests made with the commercially available alloys, it was found that difficulties were encountered such that castings made therefrom were of limited life, for example, standing up for about three months or somewhat more, or would crack after a few days' use. In particular, where castings were desired that would operate for long periods of time at elevated temperatures of around 1150° C., it was found that the commercially available alloys and castings were unreliable or of limited life, such that commercial operations based upon their use was expensive and unsatisfactory.

The present invention provides an improved heat-resisting alloy and structures made therefrom which are inexpensive to produce as compared with heat-resisting alloys previously available, and which are capable of withstanding temperatures around 1150° C. for prolonged periods of time and which are reliable and uniform such that commercial operations of a satisfactory character can be based upon their use.

I have carried out an extended investigation of heat-resisting alloys and structures and I have found that the cost of satisfactory heat-resisting alloys can be greatly reduced and at the same time the durability of the alloys and castings greatly improved. I have found that the high percentage of nickel previously used in heat-resisting alloys and structures is unnecessary and that improved alloys and structures can be provided with a considerably reduced percentage of nickle and with an increased percentage of iron over that previously considered permissible in such high temperature alloys and structures. In producing such alloys, I have also found that with proper proportioning of the nickel, chromium and iron, it is possible to avoid excessive losses of chromium by oxidation, and that the scrap can be resmelted without excessive loss of chromium and with replenishment of the chromium by the cheaper high carbon ferro-chromium, instead of the more expensive low carbon ferro-chromium. The proper control of the chromium content, in conjunction with that of the nickel and iron content, permits of lowering the melting point of the alloy, so that the work can be carried out in a furnace with an oxidizing atmosphere and at a lower temperature than with the alloys previously manufactured. The new alloys can advantageously be produced in an open hearth furnace where the alloy contains 18% or less of chromium, and particularly with a chromium content of 15% or 12%, without excessive loss of chromium by oxidation and slagging, and with important advantages of economy and control as compared with the manufacture of alloys in electric furnaces such as have commonly been used for the purpose. The troublesome carbon monoxide atmosphere of the electric furnace, and the absorption of this gas by the nickle alloys, is largely overcome or obviated by the use of an open-hearth furnace; while the over-heating of the metal in an electric furnace can be avoided and unsound casting due to gas absorption practically eliminated. The use of an

open-hearth furnace also permits of handling greatly increased charges and insures a more uniform product, as compared with the small charges manufactured in an electric furnace and the increased number of charges made successively for completing a large quantity. With a large oil-fired open-hearth furnace, a sufficient charge for a large casting can be prepared and carefully adjusted as to composition and analysis before pouring. A large charge may thus be prepared in a day's time, as compared with a series of successive smaller charges, say every three hours in an electric furnace. The provision of a considerably increased charge in an open-hearth furnace thus provides castings of greater uniformity and enables large castings to be poured from a single furnace charge. It also permits the utilization of large pieces of scrap as part of the furnace charge.

The new alloys of the present invention are well adapted for manufacture and melting in open-hearth furnaces, with advantages such as those above mentioned. The new alloys and structures, moreover, are relatively free from tendency to scale when heated to high temperature, e. g. around 1150° C.

I have found that alloys with less than about 30% of nickel would tend to scale when heated to 1150° C., even when they contained as high as 20% or more of chromium. With 30% or more of nickel, however, this tendency to scale is so reduced as to be unobjectionable, particularly where the alloy contains a proper content of chromium. With around 10 to 12% of chromium, the alloy is practically non-scaling with a content of 30% of nickel. With somewhat increased amounts of nickel and chromium, for example, 15% chromium, 35% nickel, and 50% iron, the resulting alloy and structures made therefrom were much stronger, both when hot and when cold, than alloys and structures containing less iron and more nickel, for example, alloys containing around 60% nickel, such as were previously manufactured for high temperature work. Instead of finding iron in increased amounts objectionable, I have found that it is of decided advantage and gives increased strength to the alloys and castings, as well as the other advantageous properties mentioned above.

I have further found that the carbon and silicon contents of the alloys are important. In order for a casting made of the alloy to be machined, the carbon and silicon should not be above 2% each, and these percentages, while permitting machining in casting, make it somewhat brittle and for a serviceable casting capable of enduring quick temperature changes, it is important to have the carbon and silicon content below about 1% where both are present in appreciable amount. If the carbon and silicon are sufficiently low, the alloys can be rolled and forged, but for this purpose the carbon content should be below about 0.1% and the silicon at the same time below about 0.5%. Such alloys, however, are too soft for prolonged high temperature where they are required to keep their shape when repeatedly heated and cooled and when having to carry a load, and, for alloys to be used for such purposes, I find it important to use a materially increased content of carbon, or of carbon and silicon. The carbon should in general be more than 0.25% and for best results at least 0.4%. I have varied the carbon from 0.25% up to about 1½% and have obtained satisfactory casting; but for best results I prefer to use around 0.5 to 1% of carbon. With this amount of carbon I find it important to keep the silicon content relatively low, and below 1%, and I find it advantageous to use only the small amount of silicon normally present in the materials used and amounting, e. g. to about 0.2%. With this small percentage of silicon, and with around 0.5 to 1% of carbon, very satisfactory heat resisting alloys and structures can be produced having the important advantages already referred to.

In manufacturing the alloys, I deoxidize them with a suitable deoxidizer or with more than one deoxidizer. Manganese can advantageously be used for this purpose as it acts as a good deoxidizer. It may also be present in small amount in the alloy. Aluminum and magnesium may also advantageously be used in small amount as deoxidizers.

Other metals such as cobalt, molybdenum and tungsten can also be used in small amount; when used in large amount they have a considerable modifying influence upon the alloys and castings. Titanium, zirconium, vanadium, etc. can similarly be used in small amount. All of these additions are of no particular advantage.

In manufacturing the castings, I have found it of advantage to use a chill, although satisfactory castings can be manufactured without their use.

In the course of my investigations, I have made a large number of alloys and have varied the different ingredients. As a result of these investigations, I consider that in general the various ingredients should be present in approximately the following proportions:

	Per cent.
Nickel	30 to 40
Chromium	12 to 18
Iron	38 to 56
Carbon	0.5 to 1.5

The alloys made with these proportions of the ingredients and suitably deoxidized have

been used in the manufacture of cylinders for use at temperatures of 1000 to 1200° C. with carbonaceous material on the inside and oxidizing flame on the outside, and such cylinders have been in practically continuous use for about one year's time and have been free from the limitations and objections of similar cylinders previously manufactured, and, after one year of continuous use are still giving satisfactory service and have operated without noticeable deterioration. These cylinders were approximately 13½ feet long, 15 inches in diameter and weighed about 2600 pounds each. The following table gives the composition of certain of these cylinders and illustrates some of the variations of their composition:

No.	Ni	Cr	Fe	C	Mu
1	40	20	38	0.75	0.75
2	40	15	43	.75	.75
3	40	12	45	.75	.75
4	35	20	43	.75	.75
5	35	15	48	.75	.75
6	35	12	51	.75	.75
7	30	20	48	.75	.75
8	30	15	53	.75	.75
9	30	12	56	.75	.75
10	35	15	48	.5	.75
11	35	15	48	1.0	.75
12	35	15	47	1.5	.75

Various intermediate compositions were similarly used and were found equally satisfactory. The presence of manganese was not found essential. Below about 30% of nickel objectionable scaling tends to take place, so that I consider that content of nickel as about the minimum The chromium should be at least about 10% and I consider 12% desirable for commercial operations. An alloy containing 30% nickel, 12% chromium and about 55% iron will stand up against both oxidizing and reducing heat at temperatures around 1150° C. for as long as a year or more and apparently for an indefinitely longer time without any appreciable deteriorating effect. I consider these proportions of nickel and chromium, however, about the lower limit for this temperature and I prefer to use 35 to 40% of nickel with 12% of chromium or 30 to 35% of nickel with 15% of chromium. In general, a nickel content of more than 40% and a chromium content of more than 18% are unnecessary and undesirable as they increase the cost and the difficulty of the furnace operations and of the resmelting of the scrap metal; while increased amounts of iron appear desirable for giving increased strength to the castings made from the alloys.

The importance of being able to make a heat-resisting alloy in accordance with ordinary foundry practice will be readily appreciated by those skilled in the art. With high nickel and high chromium contents, this is impossible, as they require an electric furnace and a molding and casting practice that is even more difficult than steel casting and resembles wrought iron casting. The melting point of alloys high in nickel and chromium when practically free from carbon and silicon is said to be around 1600° C. or higher, whereas the new alloys of the present invention melt at around 1300 to 1500° C. and for the most part below 1400° C. This lower melting temperature greatly facilities the working of the alloys and their preparations for the manufacture of castings.

The alloys and structures of the present invention present the further important advantage of small contraction and expansion on cooling and heating. This contraction is only about one-eighth of an inch per foot as compared with about one-fourth inch per foot or more for alloys as previously manufactured high in nickel and low in carbon.

Another advantage which the alloys of the present invention present is the decreased trouble from gas-absorption and deoxidizing as compared with alloys containing, for example 50 to 60% of nickel.

The new alloys and castings of the present invention, accordingly, present many practical advantages over similar alloys and structures previously known. They can be manufactured at a greatly reduced cost of manufacture; they are capable of withstanding high temperatures for long periods of time; they can be manufactured in an open hearth furnace; low priced ferro chrome high in carbon can be used in their manufacture and in resmelting the scrap; the alloys are much stronger both hot and cold than alloys containing less iron; the alloys have the advantage of a small expansion and contraction coefficient; the alloys have proved uniformly reliable in operation; and the alloys and structures made therefrom present other important advantages such as those hereinbefore referred to.

I claim:

1. Heat resisting alloys containing from 10 to 20% of chromium, 30 to 40% of nickel, from 0.4 to 1.5% carbon, less than 1% silicon and the remainder for the most part iron.

2. Heat resisting alloys containing 12 to 18% chromium, 30 to 40% nickel, 0.5 to 1% carbon, less than 1% silicon and the remainder for the most part iron.

3. Heat resisting alloys and containing from 10 to 15% of chromium, 30 to 40% of nickel, 0.4 to 1.5% carbon, less than 1% silicon and the remainder for the most part iron.

4. Heat resisting structures made of the alloys specified in claim 1.

5. Heat resisting structures made of the alloys specified in claim 2.

6. Heat resisting structures made of the alloys specified in claim 3.

7. Cylinders adapted for high temperature work made of the alloys specified in claim 1.

8. Cylinders adapted for high temperature work made of the alloys specified in claim 2.

9. Cylinders adapted for high temperature work made of the alloys specified in claim 3.

10. Heat resisting structures made of the alloys specified in claim 1, said structures being adapted to withstand a temperature of 1150° C. for more than one year's time.

11. Cylinders adopted for high temperature work made of the alloys specified in claim 1, said cylinders being adapted to withstand a temperature of 1150° C. for more than one year's time.

In testimony whereof I affix my signature.

NOAK VICTOR HYBINETTE.