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HEAT RESISTING ALLOYS

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The present invention relates to heat resistant alloys and to articles constructed wholly or in part thereof.

The applicant has previously found that the heat resistance of alloys which are already heat resistant and which contain as main constituents one or more metals of the iron group and in addition one or more metals of the chromium group as well as aluminum if desired, can be improved by a small addition of calcium. The calcium addition lies between about 0.05 and 2%.

Further, it has also been found that an addition of 0.02 to 1.2% of cerium is also effective in the same way. An addition of rare earth metal to heat resistant alloys for the improvement of their heat resistance is the object of applicant's U. S. Patent No. 2,067,569. This improvement of the heat resistance so operates that by the addition of calcium or cerium the time for which, at a given temperature, a heating conductor, for example, of the said material can be maintained at this temperature without burning out is greater, or with the same life period, that is to say the period until burning out, the temperature of operation with the calcium-containing or cerium-containing materials can be chosen higher. As basis alloys there may be employed, for example, the known chrome-nickel alloys with about 50 to 90% nickel, 10 to 35% chromium and iron from traces to 40%. If desired, these alloys may contain in addition one or more of the metals cobalt, molybdenum and tungsten from a small but effective amount to 20% of each, the total amount of them however not exceeding 20%, and, for example, small contents of manganese or silicon (up to about 2%). For instance, the basis alloys may contain as main constituents about 80% nickel and 20% chromium or 65% nickel, 15% chromium and 20% iron or 35% nickel, 20% chromium and 45% iron besides, for example, small contents of manganese or silicon (up to about 2%).

Further, for example, use may be made, as basis alloys, of chromium-iron-aluminum alloys, the chromium content of which varies between 9 and 35%, and the aluminum content between 4 and 12%, for example an alloy with 5 to 8% aluminium and 15 to 35% chromium, especially 30–35% chromium.

The further investigations of the applicant have now established that a more far-reaching considerable improvement of the heat resistance of such materials can be obtained when to these calcium and cerium are added simultaneously, in that either with a particular calcium content a small cerium addition is made or with a particular cerium content a small calcium content is incorporated. The additions of calcium and cerium can be between from 0.02 to 2% of each of these metals. However, the sum of the calcium and cerium should not substantially exceed 2%. It has been found that by the simultaneous addition of calcium and cerium not only the individual actions which correspond to the actions of the sum of these two additions result, but the heat resistance is still further considerably increased over the total action to be expected. In particular, by the simultaneous addition of calcium and cerium, alloys are obtained which are more readily worked up and with better yields than is the case when the same heat resistance is attained by a corresponding addition of one of the two alone. As a result of this relatively better adaptability for working up it is possible to increase to some extent the improving addition by simultaneously adding an alkaline earth metal and a rare earth metal, whereby a higher heat resistance is obtained than can be practically obtained by the individual additions.

The test of the heat resistance is conducted in a customary manner by spiralising wires of the various materials of 0.4 mm. thickness into small spirals mounting them freely in the horizontal position and then heating them to the same temperature by the passage of a current with two minutes' current on and two minutes' current off alternately, the temperature being maintained constant by subsequent regulation of the voltage. A note is made for each material of the number of hours for which it can be maintained at the stated temperature prior to burning out. This period is defined as the comparative life period at the particular temperature.

When, for example, the life period of an alloy which consists essentially of 80% nickel and 20% chromium is represented by the figure 100 then the life periods with alloys with the same basic composition but with contents of calcium and cerium are as follows:

With 0.2% calcium	600
With 0.2% cerium	157
With 0.1% calcium+0.1% cerium	857

The said alloys find use for electrical heating purposes and in particular for such purposes in which particularly high requirements as to temperature are made. They can be employed up to temperatures of 1200° C.

The following examples may be given for the composition of alloys according to this invention:

I

	Per cent	
Chromium	10	to 30
Iron	0	to 50
Calcium	0.02	to 2
Cerium	0.02	to 2

Remainder substantially nickel with small additions for desoxidation or for improving the workability.

II

	Per cent	
Chromium	18	to 25
Especially	18	to 22
Cerium	0.02	to 2
Calcium	0.02	to 2

Remainder substantially nickel with small additions for desoxidation or for improving the workability.

III

	Per cent	
Chromium	12	to 18
Especially	14	to 17
Iron	10	to 22
Especially	18	to 22
Cerium	0.02	to 2
Calcium	0.02	to 2

Remainder substantially nickel with small additions for desoxidation or for improving the workability.

IV

	Per cent	
Chromium	15	to 25
Especially	18	to 22
Iron	30	to 50
Especially	43	to 47
Cerium	0.02	to 2
Calcium	0.02	to 2

Remainder substantially nickel with small additions for desoxidation or for improving the workability.

V

	Per cent	
Aluminum	4	to 10
Chromium	5	to 40
Cerium	0.02	to 2
Calcium	0.02	to 2

Remainder substantially nickel with small additions for desoxidation or for improving the workability.

Calcium and cerium are essentially given as examples. The calcium can be wholly or partly replaced by magnesium, barium or strontium, (defined as alkaline earth metals), and cerium can be wholly or partly replaced by other rare earth metals, in particular those of the cerium group or by the so-called cerium mixed metal. By cerium mixed metal there is understood the alloys obtained in commerce consisting of cerium with other metals of the cerium group.

The simultaneous additions of zirconium (up to 2%, or thorium (up to 5%) or both seem still to improve to a certain degree the workability with the same heat resistance.

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