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3,464,815
NON-MAGNETIC IRON-NICKEL-CHROMIUM-MOLYBDENUM ALLOY, AND WATCH SPRINGS OBTAINED WITH THIS ALLOY

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 No Drawing. Filed June 22, 1967, Ser. No. 647,956
 Claims priority, application France, July 12, 1966, 69,163

Int. Cl. C22c 39/20, 39/50

U.S. Cl. 75-124

3 Claims

ABSTRACT OF THE DISCLOSURE

A non-magnetic alloy having a thermo-elastic coefficient of zero or approximately zero, and having the following composition by weight: 36.5 to 39.5% of nickel, 1.5 to 4.5% of chromium, 1.5 to 3% of molybdenum, 0.75 to 1.25% of aluminium and 2 to 3% of titanium, the remainder being iron, together with very small quantities of carbon, silicon, manganese, sulphur and phosphorus. Watch springs are made of this alloy.

Watch springs are characterized by four parameters well known to those who specialise in watch-making, namely the heat coefficient, isochronism factor, position distances and secondary error.

The heat coefficient is a basic parameter characterizing the sensitivity of the spring to variations in ambient temperature. The other three parameters will not be described here, since they are not directly concerned with the invention.

The heat coefficient is dependent on the thermoelastic coefficient of the alloys used for the manufacture of the spring. The thermoelastic coefficient indicates the effect of temperature variations on the modulus of elasticity of the alloys.

One of the aims in the manufacture of a watch spring is to obtain a zero heat coefficient. This can be done by using an alloy having a zero thermoelastic coefficient under the operating conditions of the spring.

One of the solutions of this problem already proposed by the applicants is to make these springs of a type of alloy known as "Elinvar," which is a trademark filed in the name of Société Metallurgique d'Imphy.

The nominal composition of an alloy of this kind is as follows:

	Percent	
C	0.7	50
Si	0.3	
Mn	1.9	
Ni	32	
Cr	10	55
W	3.5	
Fe	Remainder	

In order to increase the elasticity characteristics of watch springs, the Société Metallurgique d'Imphy has produced alloys whose elastic limit is considerably higher than that of Elinvar alloys. These new alloys are known as Durinval, a trademark filed in the name of Société Metallurgique d'Imphy.

One of the typical compositions of these alloys is as follows:

	Percent	
C	Minimum	
Si	Minimum	
Mn	Minimum	
Ni	42	70
Cr	5.4	

	Percent
Ti	2.5
Al	1
Fe	Remainder

5 Durinval alloys are distinguished from Elinvar alloys in particular by their hardening mechanism. The mechanical characteristics of Elinvar are produced by appropriate heat treatment during which chromium carbides are precipitated, while titanium nickelides and aluminium nickelides are precipitated in the case of Durinval. This essential difference in the hardening mechanisms of the two types of alloy is, of course, directly connected with differences in composition, which a comparison of the above two analyses will reveal. Quite apart from their higher elastic limit, Durinval alloys, like Elinvar alloys, have, of course, a substantially zero thermoelastic coefficient in the region of ambient temperature.

10 But they cannot be used to make watch springs whose movement is not mechanical but electrical. For watch springs with electrical movements must be non-magnetic at ambient temperature, whereas Durinval alloys are highly magnetic under these conditions. Their Curie point, i.e. the temperature at which the alloy passes from the ferromagnetic to the paramagnetic state, is about 150°.

15 This invention relates to a new group of alloys that have the usual features of conventional Durinval alloys, but are non-magnetic at ambient temperature.

20 The applicants have found that the Curie point of Durinval alloys can be greatly reduced by appropriate additions of molybdenum, while all the desired features, and in particular a zero thermoelastic coefficient, are preserved in the resulting material by adjusting the contents of the other elements.

25 The invention relates to a non-magnetic alloy characterized in that it is composed of the following, by weight: 36.5 to 39.5% of nickel, 1.5 to 4.5% of chromium, 1.5 to 3% of molybdenum, 0.75 to 1.25% of aluminium and 2.3% of titanium, together with very small quantities of carbon, silicon, manganese, sulphur and phosphorus, the remainder being iron.

30 The invention also relates to watch springs made of this alloy.

35 The following composition by weight of an alloy according to the invention may be given as an example: carbon 0.005%, silicon 0.34%, manganese 0.16%, nickel 38.4%, chromium 3.37%, molybdenum 2%, titanium 2.46%, aluminium 0.96% and iron 52.29%, the remainder being sulphur and phosphorus. The Curie point of this alloy is below 18° and it is practically non-magnetic at ambient temperature, having a zero thermoelastic coefficient.

40 The research on which the invention is based has shown that the contents of the constituent elements of the alloy must be adjusted within the following limits to obtain a set of properties similar to those of the alloy mentioned above by way of example:

	Percent
Nickel	36.5-39.5
Chromium	1.5-4.5
Molybdenum	1.5-3
Aluminium	0.75-1.25
Titanium	2-3

45 The remainder is iron, carbon, silicon, manganese, sulphur and phosphorus in very small proportions.

50 To obtain the best results within the composition ranges indicated above, account must be taken of the sometimes contradictory effects on the Curie point of variations in the contents of the various elements. Within the composition range in question, additions of nickel raise the Curie point, while additions of chromium, molybdenum, titanium and aluminium lower it.

Account must also be taken of the effect on the Curie point of the manner in which the alloy hardens during its treatment. The precipitation of titanium nickelides and aluminium nickelides makes the matrix of the alloy relatively poor in nickel, and is therefore accompanied by a lowering of the Curie point.

The invention is not, of course, limited by the details of the process that have just been described. These may be modified without going beyond the scope of the invention.

I claim :

1. Non-magnetic iron-nickel-chromium-molybdenum alloy, characterized in that it is composed, by weight, of 36.5 to 39.5% of nickel, 1.5 to 4.5% of chromium, 1.5 to 3% of molybdenum, 0.75 to 1.25% of aluminium and 2 to 3% of titanium, the remainder being iron, together with very small quantities of carbon, silicon, manganese, sulphur and phosphorus.

2. A non-magnetic alloy as claimed in claim 1, characterized in that it is composed by weight of 38.4% of nickel, 3.37% of chromium, 2% of molybdenum, 0.96%

of aluminium, 2.46% of titanium, 52.29% of iron, 0.005% of carbon, 0.34% of silicon and 0.16% of manganese, the remainder being sulphur and phosphorus.

3. Watch springs, characterized in that they are made of a non-magnetic iron-nickel-chromium-molybdenum alloy, composed, by weight, of 36.5 to 39.5% of nickel, 1.5 to 4.5% of chromium, 1.5 to 3% of molybdenum, 0.75 to 1.25% of aluminium and 2 to 3% of titanium, the remainder being iron, together with very small quantities of carbon, silicon, manganese, sulphur and phosphorus.

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U.S. Cl. X.R.

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