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ALLOY.

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This invention relates to spring alloys and its object is an alloy which will retain resiliency when heated to a high temperature.

This application is a continuation in part of my copending application, Serial No. 610,019, filed December 30, 1922.

There has been considerable trouble in the past in obtaining a spring metal which would not only hold considerable resiliency when heated to a high temperature, but would further not become decidedly crystalline and therefore brittle upon cooling. For instance, in making vacuum tubes the springs which hold the filaments in position become heated to a red heat during the baking process, so that ordinary spring metal becomes soft and loses its resiliency and the springs therefore become distorted.

In accordance with the features of this invention, there is provided a group of alloys comprising metals of the iron and tungsten groups, and in some instances, copper. It has been found that alloys composed of metals of the iron and tungsten groups in accordance with the invention, possess the strength, hardness and resiliency necessary in spring metals, and when properly proportioned will not become sufficiently brittle after being heated to a red heat to prevent their use for springs which may be subjected to high temperatures, so that they make exceedingly good springs for use in holding the filaments in vacuum tubes, for example. The strength, hardness, resiliency and crystalline character of this group of alloys make them applicable over a wider range of conditions and at more varied temperatures than is possible in the case of ordinary spring metals.

The proportions of metals of the iron and tungsten groups which may be employed in forming these alloys may be considerably varied, changes in such proportions, of course, varying the strength, hardness, resiliency and crystalline character of the particular alloy formed. It has been found that, as a general rule, the higher the tungsten group content the greater appears to be the amount of resiliency retained after heating to a red heat. While greater resiliency appears to be retained with higher tungsten group content, it has further been noted that, as a rule, the alloy shows a tendency toward becoming more brittle with higher tungsten group content.

Nickel has been found to be an advantageous metal of the iron group for use in combination with metal of the tungsten group. Alloys composed of a comparatively large amount of nickel and a smaller amount of either chromium, molybdenum or tungsten have been found to be satisfactory. An alloy, for example, composed of 3.2 atomic percent tungsten or molybdenum and 96.8 atomic percent of metal of the iron group forms a satisfactory spring for high temperature use. As the tungsten group content is increased, approaching forty weight percent, the brittleness of the alloy formed is found to increase rapidly. This brittleness, however, may be offset without substantially decreasing the resiliency by replacing some, or if desired, all, of the nickel by iron and cobalt and by using a mixture of tungsten, molybdenum and chronium instead of a single metal from the tungsten group. Springs formed, for instance, of metallic compositions such as

	Per cent.
Cobalt	15
Chromium	15
Tungsten	5
Nickel	54
Iron	10
Manganese	1
Nickel	33.5–34
Iron	25
Molybdenum	25
Chromium	15
Manganese	1–1.5
Nickel	60
Tungsten	40
Nickel	80
Chromium	20
Nickel	90
Tungsten	10
Nickel	95
Molybdenum	5

have been found to retain a high degree of resiliency after being subjected to a red heat and further do not become seriously brittle after several heatings. The several examples given are those which have been found to possess the desired characteristics. However, no one of these compositions can be said to be preferred, for all purposes, over the others, but percentages, intermediate

those given or differing widely from them, and yet within the limits defined by the claims, may be used to secure the advantages of the invention, the percentages chosen depending upon the particular conditions met in each instance.

The preferred proportions will depend upon the use to which the spring is to be applied. It is, of course, always desirable to have the tungsten group content as high as possible for high temperature work, and it will depend upon the restrictions placed on the crystalline structure as to the amounts of nickel and tungsten or molybdenum which are respectively replaced by iron or cobalt and chromium. It will be appreciated, therefore, that it is not intended to impose any restrictions upon the proportions of the ingredients employed, other than those set forth in the claims.

Further, in some cases it may be desired to produce a spring alloy which will retain considerable resiliency and which will possess an even less brittle structure than obtainable by proportioning metals of the iron and tungsten groups, as above. In such cases it has been found that additions of copper, up to about 30%, in place of iron group metal produce a satisfactory alloy.

In the preparation of springs from these alloys, the alloy is first annealed, preferably in an inert gas or vacuum, at approximately 1000° C., after which it is cooled and formed into a spring. By such treatment the alloy becomes stabilized in the annealing process so that after the subjection of the resultant spring to a series of heatings at red heat, a high degree of resiliency will be retained. The alloys of this invention have been found to retain resiliency even after a series of heatings at approximately 700° C. They have further been found to be reliable for use in vacuum tubes, for example, which must be subjected to a good red heat.

It is generally advantageous to add a small portion of manganese as a de-oxidizer.

Though directed specifically to use in springs which are to be subjected to high temperatures, it is evident that the alloys of this invention may be employed for any purpose in which a metallic composition is required which combines strength, hardness and the retaining of a high resiliency after treatment at a red heat.

What is claimed is:

1. A spring to retain considerable resiliency at a red heat, composed of an alloy comprising as essential elements thereof, an amount of metal of the tungsten group at least as small as 40%, and metal of the iron group.

2. A spring for use at temperatures in the vicinity of red heat composed of a metallic composition containing as essential elements thereof metals of the iron and tungsten groups and copper, the amount of copper being at least as small as 30% and the amount of metal of the iron group being at least as small as 95%.

3. A high temperature spring for use at red heat temperatures, composed of an alloy comprising as essential elements thereof the following metals in substantially the following proportions by weight:—metal of the iron group 60–95%, metal of the tungsten group 5–40%.

4. A high temperature spring to retain appreciable resiliency at red heat temperatures, composed of an alloy comprising as essential elements thereof the following metals in substantially the following proportions by weight:—copper at least as small as 30%, metal of the iron group 60–95%, metal of the tungsten group 5–40%.

5. A high temperature spring to retain appreciable resiliency at red heat temperatures, composed of an alloy comprising as essential elements thereof substantially 60–95%, of nickel with metal of the tungsten group.

6. A high temperature spring to retain appreciable resiliency at red heat temperatures, composed of an alloy comprising as essential elements thereof the following metals in substantially the following proportions by weight:—metal of the tungsten group, at least as small as 40%; metal of the iron group, at least as great as 60%.

In witness whereof, I hereunto subscribe my name this 17th day of September A. D., 1924.

GEORGE O. SMITH.