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METHOD OF ADJUSTING THE TEMPERATURE COEFFICIENT OF RESONATORS

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3 Claims. (Cl. 148—21.5)

This invention relates to steel alloy resonators and has for its object to provide a method to compensate for changes in pitch or vibration of such resonators resulting from changes in temperature.

In tuning forks made from metals generally used for fabricating such devices, an increase in temperature of the fork causes it to expand in all its dimensions. The effect of this expansion is to increase the pitch or vibrational frequency of the fork.

An increase in temperature of the fork also changes the elasticity or stiffness of the fork. In general, the elasticity decreases with an increase in temperature and the effect of this decrease in elasticity is to decrease the frequency of the fork.

Since the change in frequency due to the change in elasticity is greater than the change in frequency due to expansion, the net result of an increase in temperature is a decrease in the frequency or pitch of the fork.

This applies to most materials commonly used in fabricating tuning forks.

However, in the case of chromium-steel-alloy tuning forks or molybdenum-steel-alloy tuning forks, which are known as low-temperature-coefficient forks, the foregoing net result does not hold. While an increase in temperature of such forks increases the pitch or frequency due to expansion, the elasticity or stiffness can either increase or decrease depending upon the exact composition of the alloy used in making the fork.

Therefore forks fabricated from low-temperature-coefficient alloys can have either a positive or negative temperature coefficient, and while theoretically it is possible to produce forks of this special class with zero temperature coefficients, this is not possible in practice because the composition of the fork alloy cannot be controlled accurately enough. After being fabricated, the temperature coefficients vary over a range of plus or minus two or three parts in a million per degree centigrade.

The method of my invention is concerned with tuning forks made from such special alloys; that is, from low temperature coefficient of frequency materials, and moreover to such forks which after fabrication are measured and found to have a small negative temperature coefficient, and the method provides a simple means for making a small adjustment in the temperature coefficient of such tuning forks.

I have discovered that by means of heat treatment, the variation of frequency with temperature is reduced in forks having a negative coefficient.

The method of this invention permits bringing the coefficient, over a limited temperature range at least, as close to zero as desired.

The steel alloy tuning forks to which I apply my method are made, for example, from a series of chromium-nickel steels or a series of molybdenum-nickel steels, which are known as low temperature coefficient of frequency materials.

The method of this invention involves a series of heat treatments of the fork and consists in heating the fork slowly in vacuum or an inert gas to approximately 950° C., maintaining it at this temperature for approximately three hours and finally allowing it to cool slowly to room temperature, and then repeating this treatment. After such treatments it will be found that the temperature coefficient of the fork under treatment will have been changed in a positive direction. The number of treatments is, of course, determined by the results desired.

The extent of the change in the temperature coefficient of a fork such as used in carrier telephone system oscillators can be seen from the following data which were obtained in a test with a 4000-cycle molybdenum alloy fork. The temperature coefficient of this fork was measured after having been machined and adjusted in frequency. It was then given three successive anneals, and the temperature coefficient remeasured after each treatment.

State	Temp. coef. X 10 ⁻⁴ /° C.
Before anneal	-1.3
After 1st anneal	-0.5
After 2nd anneal	+0.4
After 3rd anneal	+0.9

The above table indicates how successive anneals progressively shift the temperature coefficient from a negative to a positive value.

There is only one type of alloy for making the low temperature coefficient of frequency tuning forks with which this invention is concerned. These two alloys belong to that type. One is a chromium-nickel-steel alloy well known as elinvar. The other is a molybdenum-nickel-steel alloy.

Although I have selected tuning forks as the embodiment of my invention as above described, I desire it to be understood that my invention is not so limited, but is equally applicable to bars, discs, reeds, and in fact any resonator of this type.

What is claimed is:

1. The method of making adjustments in the temperature coefficient of frequency of resonators

with negative temperature coefficients made from molybdenum-nickel-steel alloys which consists in subjecting the resonator to a series of anneals.

2. The method of making adjustments in the temperature coefficient of frequency of tuning forks with negative temperature coefficients made from molybdenum-nickel-steel alloys which consists in heating the fork slowly in vacuum to approximately 950° C., maintaining it at this temperature for approximately three hours, and finally allowing it to cool slowly to room temperature.

3. The method of making adjustments in the temperature coefficient of frequency of molybdenum-nickel-steel alloy tuning forks with negative temperature coefficients made from low temperature coefficient of frequency alloys which consists in heating the fork slowly in vacuum to approximately 950° C., maintaining it at this temperature for approximately three hours, and finally allowing it to cool slowly at room temperature, and successively repeating this treatment.

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