

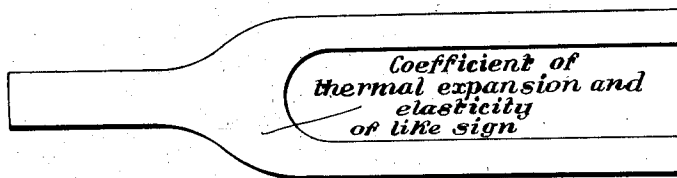
June 17, 1930.

A. KAROLUS

1,763,853

MECHANICAL OSCILLATOR OF CONSTANT FREQUENCY VALUE

Filed Nov. 25, 1927



Inventor
AUGUST KAROLUS
By *W. T. Grove*
Attorney

UNITED STATES PATENT OFFICE

AUGUST KAROLUS, OF LEIPZIG, GERMANY, ASSIGNOR TO RADIO CORPORATION OF AMERICA, A CORPORATION OF DELAWARE

MECHANICAL OSCILLATOR OF CONSTANT-FREQUENCY VALUE

Application filed November 25, 1927, Serial No. 235,761, and in Germany December 22, 1926.

The invention relates to a method to keep the frequency of mechanical oscillators, which are required to be of great accuracy, constant. The same is applicable, for instance, to tuning forks which serve for the purpose of accurate synchronization of drives of all kinds, for instance, for picture transmission; furthermore, for pilot tubes which are expected to keep the frequency of an oscillation system, such as a valve transmitter, at a constant value. It is known to the prior art that tuning fork oscillators as time tappers may be used for purposes of the said sort in various circuit arrangements. In order that in such a scheme the highest possible constancy of frequency may be insured, the aim generally has been to make tuning forks of this kind from a sort of material exhibiting the lowest possible coefficient of expansion. The idea was that the thermal coefficient of expansion would diminish the frequency with rising temperature as a result of longitudinal changes and the shifting of particles of the vibrating parts associated therewith, and that the said coefficient must for this reason be kept as low as possible.

The temperature coefficient of frequency in the case of a tuning fork made from ordinary steel ranges approximately between 1 and 2×10^{-4} . Since in perfect synchronization in picture transmission comprising the use of local time tapper oscillators independent of each other makes at the most a departure of 1/100,000 permissible, it follows that on the basis of the above temperature coefficient of frequency it would be necessary to keep the temperature of tuning forks constant to within 1/10 of one degree. This is very difficult in practice, and possible only with very complicated means.

It is an object of the disclosure of the present invention to insure constancy of frequency to a far greater degree even in the presence of greater temperature changes and by the aid of simpler means. To the end of precluding the temperature influence upon the vibrating tuning fork, according to former practice, materials of very low coefficients of expansion were used, such as the well known materials known as invar or indi-

latans. Whereas the selection of such a material in the case of pendulums, which are dependent for their period of vibration only upon the length, has been attended with success, it has proved a failure for such mechanical oscillators whose frequency is governed both by mass and elasticity. For instance, in the case of tuning forks made from such material, it has been found that the temperature coefficient of frequency turns out to be even greater than for ordinary grades of steel; indeed, it may range up to 3×10^{-4} . The underlying reason is that while the longitudinal extension becomes vanishingly small with the temperature, the existent temperature coefficient of elasticity substantially remains unvaried. This so-called "thermo-elastic" coefficient is negative for such substances as for instance, invar. Generally speaking, in the case of positive coefficients of expansion, a negative thermo-elastic coefficient means that the action of a decrease in elasticity of the material and that of a growth in length and attendant shifting of masses upon the frequency become added; indeed, the ensuing frequency decrease is the joint result of both influences. An oscillator material with vanishingly low coefficient of expansion, for instance, invar, as before pointed out, may exercise by virtue of its thermo-elastic coefficient a more marked frequency influence with temperature than in the case of a material having an appreciable thermal extension in length as ordinary steel.

The present invention is based upon the clear appreciation of the said conditions, and the same essentially resides in that for the making of tuning forks or other mechanical oscillators materials are used whose thermal coefficient of expansion and thermo-elastic coefficient have the same sign. For instance, if the same is positive, then any decrease in frequency due to a growth in length of the vibrating structure will be more or less offset by the frequency-raising action of increasing elasticity. This compensation may be rendered perfect, or practically so, by various ways and means; indeed, to such an extent that a resultant temperature coefficient of frequency 10^{-5} to 10^{-6} is attained.

One way to that end consists in that the tuning forks or other oscillators are made from uniform material in which the coefficient of expansion and the thermo-elastic coefficient are both positive at the proper relationship. As an example of a grade of steel suitable in the above sense may be mentioned a chrome-nickel steel alloy, containing about 30% nickel and from 10 to 12% chromium, it being presupposed that the distribution of masses or particles is similar to that of an ordinary prong-type tuning fork, while for other shapes of the oscillators other alloying proportions may be found.

Of course, fundamentally speaking, the invention, consisting essentially, as shown by the single figure of the drawing in the selection of materials of coefficients of expansion and thermo-elasticity of equal sign may be practiced also in this way that substances are chosen in which both coefficients are negative.

Another way of carrying the basic idea of the invention into practice consists in that the oscillator is not made from a uniform alloy, but is composed of different metals. By choosing a plurality of metals of different thermal longitudinal expansion or different thermo-elastic coefficient, conditions may be made so that the compensation is practically perfect. In this connection, another improvement is insured by that not only different materials are composed in a purely additive way, but that the distribution of materials and masses is chosen in a special way; for the influence of each mass possessing a definite variation in thermal respect, in length and elasticity, will differ according to its local arrangement within the oscillating structure or system.

Having now described my invention, what I claim is:

1. A mechanical vibrator for maintaining constant frequency under varying conditions of temperature which is formed from a metallic substance whose coefficients of expansion and elasticity are of like sign.

2. A mechanical vibrator for maintaining constant frequency under varying conditions of temperature which is formed from a ferrous alloy whose coefficients of expansion and elasticity are of like sign.

3. A mechanical oscillator having a coefficient of thermal expansion of one sign and a coefficient of elasticity of like sign, whereby temperature variations tending to change the frequency of said oscillator are compensated for by changes in the elastic properties of the said oscillator.

4. A tuning fork formed of a ferrous alloy in which changes in length of said fork due to variations in temperature, are compensated for by changes in the elastic properties of the said ferrous alloy.

5. A tuning fork formed of chrome-nickel

steel whose coefficients of thermal expansion and elasticity are of like sign.

6. A mechanical vibrator for maintaining constant frequency under varying conditions of temperature which is formed from a homogeneous metallic substance whose thermal coefficient of expansion and thermo-elastic coefficient are of like sign.

7. A mechanical vibrator for maintaining constant vibrational frequency irrespective of temperature variations which is formed from a homogeneous ferrous alloy having a thermal coefficient of expansion and a thermo-elastic coefficient each of like sign.

8. A tuning fork formed of a homogeneous steel alloy including approximately 30% nickel and 10 to 12% chromium.

AUGUST KAROLUS.