Nov. 29, 1949 A. G. COOLEY 2,489,400

TUNING FORK

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Fig. 1

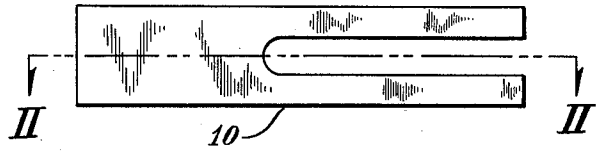
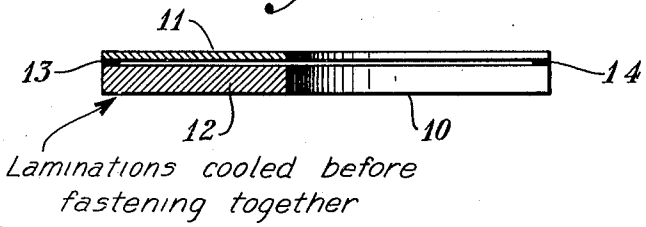



Fig. 2



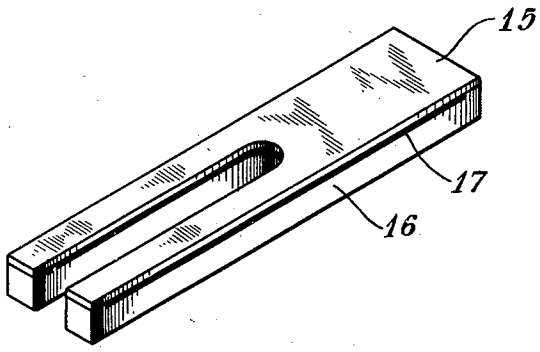




Fig. 3

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## TUNING FORK

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2 Claims. (Cl. 84—457)

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This invention relates to tuning forks, and more particularly to a temperature-compensated fork and method of making the same.

For many applications of tuning forks, it is important to stabilize the pitch or vibration frequency thereof under normal conditions of use. In order to avoid changes in vibration frequency with changes in ambient temperature, it has been proposed to construct a metallic fork of different metals having selected temperature coefficients of expansion and elasticity, the proportions of the respective metals being such as to provide a substantially constant vibration frequency over a considerable range of ambient temperatures. One of the proportions most commonly used is one part of carbon steel to about 10 parts of nickel-alloy steel, such as Invar or Elinvar.

In general terms, the object of the present invention is to improve the characteristics of a tuning fork of this character, more particularly the frequency characteristics for ambient temperature changes.

The prior bimetallic or laminated forks having laminae which were soldered or welded together in the customary manner, worked well for temperatures from plus 30° or 40° F. up to temperatures of about 150° F. It was found that below that range of temperatures, the frequency of the fork shifted rapidly. The non-linear change in frequency, particularly at the lower end of the scale, cannot be ascribed entirely to changes in the temperature coefficients of expansion or elasticity of the metallic laminae and therefore must be caused in part by the internal stresses of the laminae resulting from unequal expansion with temperature. Accordingly, another object of the invention is to reduce the internal stresses of the tuning fork when operating at low ambient temperatures.

In accordance with the preferred embodiment of the invention, the laminations of the fork are secured together only after cooling, since the useful range of the fork is thereby extended from plus 150° F. down to substantially below 0° F. It is unnecessary to solder or weld the laminae over their entire length since the desired temperature compensation is secured if the laminae are attached only at or intermediate their ends in such a manner that the fork components vibrate as a unit. Obviously, the laminae may be attached together at one end before cooling, the final weld at the opposite end being made after the cooling operation. If desired, suitable vibration dampening material may be interposed between the faces

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of the laminations to minimize spurious vibrations of the components forming the complete fork unit.

Other objects and advantages of the invention will appear from the following description of the preferred embodiments thereof shown in the accompanying drawings, wherein:

Fig. 1 is a plan view of a compensated tuning fork;

Fig. 2 is a sectional view of the fork shown in Fig. 1, taken along the section line II—II of Fig. 1; and

Fig. 3 is a perspective view of a modification.

Referring to Figs. 1 and 2, the tuning fork shown by way of example is in the form of a slotted bar 10 having opposed tines connected by a heel portion to which a rigid mount or support (not shown) may be attached. Various other conventional shapes and proportions of fork may be used in accordance with the invention. The fork comprises two laminations 11 and 12, for example of carbon steel and Invar having the desired opposite temperature coefficients of elasticity. The compensating lamination 11 and the main body portion 12 of the fork as shown differ in mass (thickness) to secure the desired proportions to provide substantially perfect temperature compensation, for example, in the proportions of one part of carbon steel to 10 parts of nickel-alloy steel. It is found that these proportions provide substantially perfect compensation for normal ambient temperatures, when the fork is mounted or shielded in such a manner as to avoid unequal heating or cooling of different parts of the fork. To this end the fork is usually enclosed in an insulated container or box. It is possible in this manner to construct a fork which vibrates at constant pitch when the temperature of the actual fork itself varies between plus 30° or 40° F. to 150° F. Other conditions being constant, the total variation of frequency over this temperature range may be made as small as about one part in 100,000 due to temperature change alone.

In many cases, for instance in airborne equipment, it is desirable to maintain constant frequency to temperatures as low as minus 30° or 40° F. In accordance with the invention, this is accomplished by reducing the internal stresses of the fork for the lower operating temperatures. The preferred method of accomplishing this result is to secure the laminations 11 and 12 together, as by soldering or welding, while the laminations are cooled to a temperature approximating the lowest temperature in the operating

range, for example, minus 40° F. The laminations need not be secured together over their entire abutting areas, but preferably are tacked together at opposite ends at the points 13 and 14. Obviously, instead of securing the laminations together at the exact points indicated, the component parts may be secured together in any manner which will permit the laminated tuning fork to vibrate as a unit. For example, a bonding area of considerable size between the respective laminations may be obtained by the use of low-temperature solder, if desired. In this manner the compensation characteristics of the fork are extended so that it will operate at constant frequency for lower ambient temperatures. In the preferred process of manufacture, ordinarily the steel compensating lamination 11 is tacked or attached to the alloy-steel lamination 12 at the heel of the fork first. Then, after cooling the entire fork to the desired extent, the laminations are spot-welded or tacked together at the tips of the tines before the parts have had a chance to warm up appreciably.

In the modification shown in Fig. 3, the laminations 15 and 16 are secured together in the same manner as the modification described in connection with Figs. 1 and 2 except that a dampening layer 17 of lead or plastic material is interposed between the laminations 15 and 16. This dampening layer is helpful where the lamination 15 is so thin that it tends to vibrate laterally when the fork is being driven.

In actual practice, a fork of the character described is normally maintained in continuous vibration by electromagnetic or other conventional means. It will be understood that the invention is not limited to a fork embodying the metals or proportions which have been described and shown in the drawings, since the invention may be applied equally well to other bimetallic or temperature-compensated tuning forks.

The low-temperature fork described may be used in conjunction with a second fork which is stabilized for high temperatures, and a thermostat employed to change over from one fork to the other as the ambient temperature changes over a wide range.



I claim:

1. A bimetal tuning fork of constant vibration frequency for ambient temperatures from minus 40° F. to plus 150° F. comprising a plurality of laminations of metals having different temperature coefficients of expansion and of elasticity, said laminations being welded or soldered together only at opposite ends thereof, the final weld being made after the laminations are cooled to a low temperature compared with the median temperature of said operating range.

2. A bimetal tuning fork of constant vibration frequency for ambient temperatures from substantially below 0° F. to plus 150° F. comprising a steel lamination and a nickel-iron alloy lamination having opposite temperature coefficients of elasticity, said laminations being welded or soldered together at opposite ends with the final weld being made after the fork is cooled to a temperature approximating the lowest ambient operating temperature.

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