Feb. 14, 1950 J. R. SHONNARD 2,497,143

TUNING FORK

Filed Oct. 23, 1946

Fig. 1

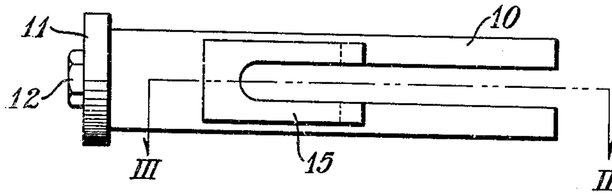


Fig. 2

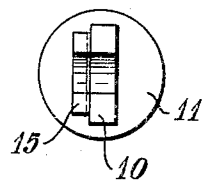


Fig. 3

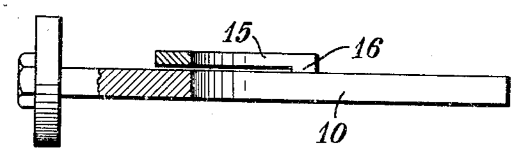


Fig. 4

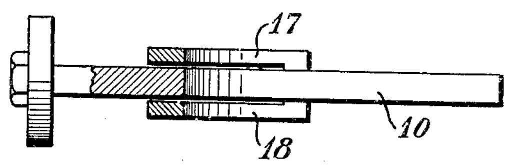
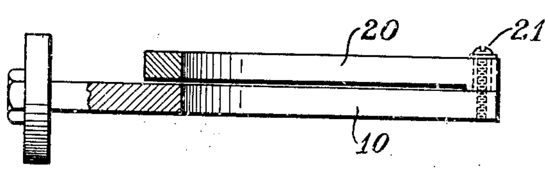


Fig. 5



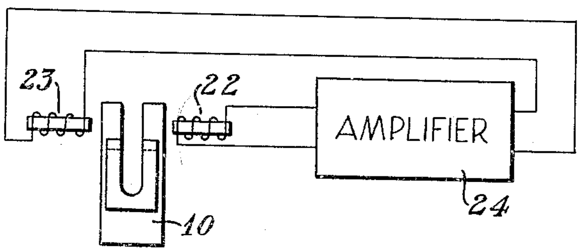


Fig. 6

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TUNING FORK

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8 Claims. (Cl. 84—457)

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This invention relates to mechanical resonators and more particularly tuning forks and the like.

For many applications of tuning forks it is important to stabilize with a high degree of precision, the pitch or vibration frequency thereof under normal conditions of use. In order to avoid changes in the vibration frequency with changes in ambient temperature, it has been proposed to construct a tuning fork of laminations of different metals, the proportions of the metals and their elastic properties being so related as to provide a substantially constant vibration frequency over a considerable range of ambient temperatures. In one fork of this type, similar bifurcated laminations of carbon steel and nickel-alloy steel are welded or brazed together over their entire opposed faces.

In general terms, the object of the present invention is to provide an improved resonator or tuning fork of this character which is easier to adjust and assemble, and which can be accurately compensated to provide a stabilized frequency characteristic over a wide temperature range.

In accordance with the invention, the bimetallic temperature-compensated fork is preferably constructed of two superposed balanced fork units, the smaller of which is mounted with its tines attached to the tines of the other element. In this manner the two forks are constrained to vibrate as a unit, the resonant frequency of the composite fork being determined by the dimensions and elastic properties of both of its component elements. Since the forks may be separately balanced before mounting one upon the other, balancing the combined fork units is practically unnecessary after assembly. After securing the fork units together in any suitable manner, the frequency is adjusted by trimming or grinding the tines.

Since one of the laminations is relatively thin in the prior construction, it has been deemed necessary to solder or weld the fork laminations over their entire areas in order to secure unvarying permanent characteristics and avoid spurious vibrations of the thinner lamination. In accordance with a further feature of the invention, the smaller element, for example of carbon steel, is made short and thick enough to impart the necessary stiffness to such element and it is then secured preferably at or near the tip ends of the tines only, to the other main element of the fork. In this manner the main body portion of the tuning fork is free to expand and contract without subjecting the compensatory element or smaller fork to longitudinal stresses. It is found that a fork constructed in this manner is stabilized over a wider range of temperatures than in the case of laminated forks employing abutting laminations of substantially identical outline or configuration secured over their entire areas.

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The dimensions of the tines depend upon the desired frequency of vibration and the ratio between the vibratory portions of the respective fork elements depends upon the temperature coefficients of expansion and elasticity of the metals employed. Thus, in the case of the commonly used carbon steel and nickel-alloy steel such as Invar or Elinvar, the proportion of carbon steel to nickel-alloy steel is approximately in the ratio of one to ten. The cross-section of the tines of each fork may vary from a square to a rectangular shape but the thickness of each fork should be sufficiently great so that the tines are stiff in the direction transverse to normal vibration, and neither fork tends to vibrate as a reed. The forks are attached together by soldering or welding, or by the use of screws or rivets in such a manner that the contact area is restricted lengthwise of the fork. Therefore the two fork elements are free to expand longitudinally without imparting undesired stresses to either fork. When constructed in this manner, as stated above, it is found that the vibration frequency of the fork remains constant over a wide range of temperatures.

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 fork embodying the invention;

Figs. 2 and 3 are end and sectional views of the fork shown in Fig. 1, Fig. 3 being taken along the section line III—III of Fig. 1;

Figs. 4 and 5 are sectional views similar to Fig. 3 showing two modifications of the invention; and

Fig. 6 is a diagrammatic view of a constant frequency oscillator utilizing the improved tuning fork.

Referring to Figs. 1 to 3, a tuning fork is shown comprising a main body portion or fork element 10 consisting of a bifurcated metallic bar attached to a suitable mount or support 11, as by means of a bolt 12. The fork 10 includes two symmetrical parallel tines as in the conventional tuning fork. In accordance with the invention, a compensatory metal plate in the form of a second fork 15 is mounted upon the first fork element 10. The second fork element 15 is rigidly attached to the element 10, as will be described hereinafter, so that the two fork elements vibrate as a unit at a single resonant frequency determined by the sizes and elastic properties of the vibratory portions of both forks. Thus, for example, in order to secure stabilized frequency characteristics over a wide range of ambient temperatures, the fork 10 may be constructed of nickel-alloy steel such as Invar or Elinvar, and the fork 15 of ordinary carbon steel. Since the nickel-alloy steel has a positive temperature coefficient of elasticity and the carbon steel has a negative temperature coefficient of elasticity, by controlling the ratio of the masses of the tines of the two forks, the normal frequency change of each fork resulting from changes in size and elasticity with changes in temperature may be compensated so that the composite fork has a fixed frequency of vibration over a wide temperature range.

As shown, the carbon steel fork 15 is provided with small bosses or projections preferably but not necessarily at the ends of the tines to form a contact area 16 of limited size between the two forks 10 and 15. The forks may be attached at the point 16 in any suitable manner, as by soldering, brazing or welding. If each of the forks is dynamically balanced and ground to the proper dimensions before assembly, the final frequency adjustment may be made readily by grinding the edges of one or both of the forks without disturbing the dynamic balance of the composite unit. The point of attachment may be at the ends of one or both forks, or along the lengths of the tines of both forks.

If desired, more than one compensating fork may be mounted on the main fork 10. Thus, as shown in Fig. 4, two compensating forks 17 and 18 are mounted on opposite sides of the main fork 10, each of the compensating fork elements being similar to that shown at 15 in Fig. 3. In case the masses of the compensating forks are so small that the physical dimensions are reduced much below that shown in the drawings, it is necessary to guard against the possibility of transverse vibrations of the compensating elements. This is done by keeping the thickness of the compensating elements sufficient to provide substantial stiffness against transverse vibrations. If the size of the compensatory unit is sufficiently great, the length of the tines may be increased over that shown in Figs. 3 and 4.

This modification is shown in Fig. 5 wherein the two forks are attached together at tip ends of the tines, the compensatory fork unit 20 having tines as long as the fork 10. In this instance, the forks are secured together by clamping screws 21, the ends of the tines being slotted to permit lengthwise adjustment of the compensatory fork unit, if desired. While in each modification the two forks are shown attached together in such relation that the throats of the tines are in alignment, this relation may be varied somewhat so long as the fork units are attached together so that they vibrate at a single resonant frequency.

In actual practice, a fork of the character described is normally maintained in continuous vibration by electromagnetic or other conventional means. Thus, as shown in Fig. 6, the fork 10 may be disposed between pickup and drive magnets 22 and 23 respectively, adapted to maintain the fork in continuous vibration. The terminals of the pickup magnet 22 are shown as connected to the input circuit of an amplifier 24. The output circuit of the amplifier 24 is connected to supply a constant level drive current of a frequency determined by the vibration frequency of the fork to the drive magnet 23, thus maintaining the mechanical resonator in continuous operation. The amplifier 24 may also be employed to furnish a current of constant frequency for driving facsimile equipment, timing mechanisms and other similar devices.

While I have shown several embodiments of the invention in order to explain the principles thereof, it will be understood that the invention is not limited to these specific examples. Other modifications in the sizes and arrangement of the fork elements will occur to those skilled in the art and may be made without departing from the scope of the invention as defined in the appended claims.

I claim:

1. A tuning fork comprising a plurality of superposed bifurcated elements rigidly attached together to vibrate as a single unit at a predetermined vibration frequency, the areas of contact between said elements being confined to a portion of the length of each element which is a small fraction of the total length thereof.

2. A tuning fork comprising a main bifurcated element and a second similar bifurcated element which is superposed upon and substantially shorter than the main element, each of said elements having two parallel tines of equal mass, the tines of both elements being rigidly fastened together to insure vibration of both parts of the fork as a unit and the oposing faces of the two elements being spaced apart except at the ends of the tines of said second shorter element.

3. A tuning fork comprising two superposed bifurcated elements of unequal length rigidly attached together to vibrate as a unit, each of said elements having a pair of symmetrical tines fastened to the tines of the other element and arranged with the throats in substantial alinement, the attachment of the shorter of said elements being confined to the tip ends of its tines to minimize internal stresses from longitudinal expansion of said elements.

4. A tuning fork comprising a main body portion having opposed tines, and a superposed compensatory metallic element of similar configuration mounted upon and rigidly fastened at the tip ends of its tines to the tines of the main body portion, the body portion and compensatory element being unattached at the heel ends opposite the tines to minimize internal stresses resulting from unequal expansion thereof with varying temperatures.

5. A tuning fork comprising a main metallic body portion having opposed tines, and a bifurcated compensatory metal plate superposed thereon and rigidly attached at the forked end thereof to the tines of the main body portion whereby the said body portion and metal plate vibrate as a unit and the fork frequency is determined by the elastic properties of both of said components, the point of attachment of said compensatory metal plate to said main body portion being restricted to a lengthwise contact area which is a small fraction of the length of said plate.

6. In combination, two metallic forked elements of different physical characteristics rigidly attached together in superposed relation to vibrate as a tuning fork at a single vibration frequency, said forked elements being attached only at the tines.

7. In combination, a tuning fork composed of a

metal having a positive temperature coefficient of elasticity and a second tuning fork composed of a metal having a negative temperature coefficient of elasticity, said forks being rigidly attached to each other in superposed relation to vibrate as a unit, the contact area between said forks being relatively short along the length of either of said forks to minimize internal stresses therein resulting from unequal expansion of the forks upon changes in ambient temperature.

8. In a mechanical resonator of the tuning fork type, two forks of metals having different elastic properties, the tines of said forks being rigidly attached together in superposed relation to vibrate at a single resonant frequency, said forks being unattached except at the tines so

as to be independently expansible lengthwise with changes in ambient temperature to obviate stressing of the metal resulting from unequal expansion.

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