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[33] **Switzerland**
[31] **1056/69;**
Feb. 24, 1969, Switzerland, No. 2738/69

[54] **TIMEPIECE OSCILLATORS**
7 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** **58/23,**
58/109, 310/36, 331/177
[51] **Int. Cl.** **G04c 3/00,**
H02k 33/02, H03b 3/04
[50] **Field of Search** 58/23, 23
AB, 23 V, 23 TF, 28, 107, 108, 109; 310/36;
331/177

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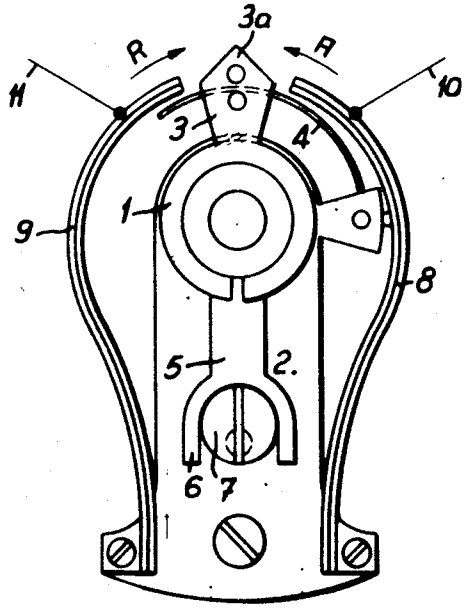
ABSTRACT: Disclosed herein is a timepiece oscillator disposed in a fluidtight enclosure at a pressure below 1 mm. of mercury, preferably of the order of 10^{-3}mm. The frequency of oscillation can be adjusted by bimetal strips operated by control means outside the enclosure. Means for maintaining and adjusting vibration of the oscillator can be included in the enclosure which forms a unit pluggable into a timepiece. For a mechanical watch, the fluidtight enclosure advantageously contains the entire movement.



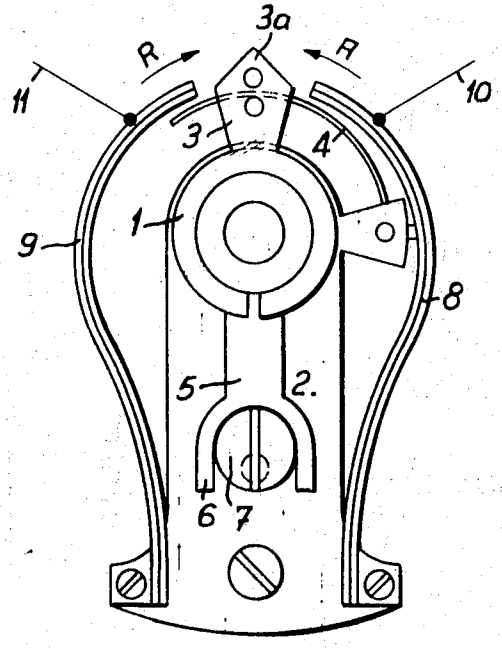


FIG. 1

FIG. 2

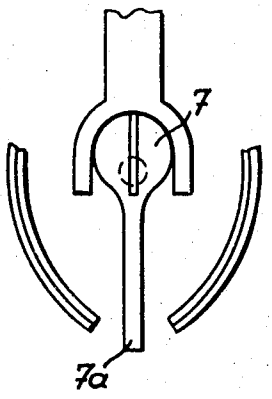
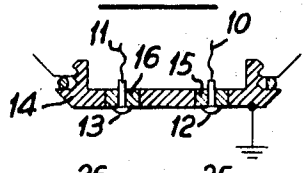


FIG. 3



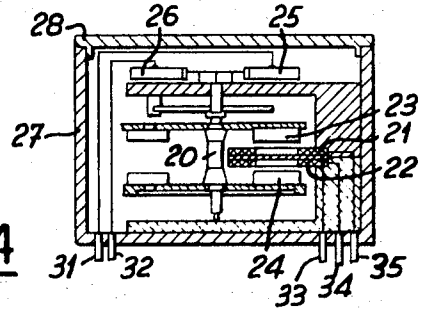


FIG. 4

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FIG.5

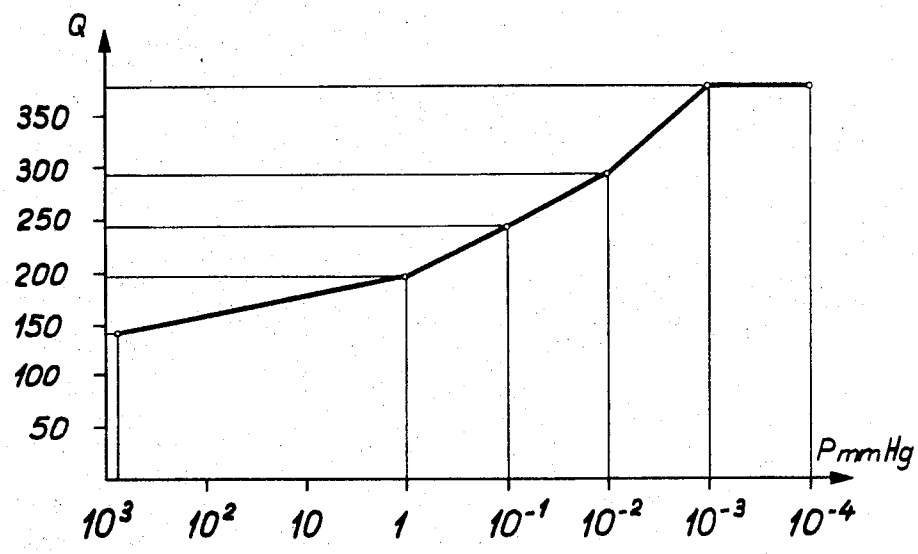
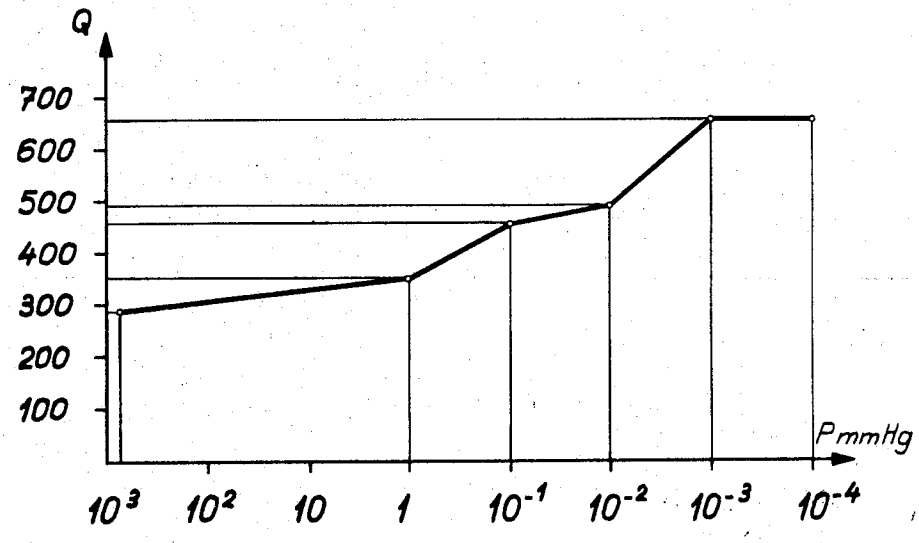


FIG.6



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TIMEPIECE OSCILLATORS

The present invention relates to timepieces comprising a timekeeper constituted by an oscillator working within an enclosed space at a pressure below atmospheric.

Watches having a movement working in a sealed case under reduced pressure are already known, the movement being indistinguishable from conventional movements, and the pressure being reduced to eliminate risks of oxidation of the movement and the lubricating oils.

The maintenance of this reduced pressure requires a perfectly sealed case, carefully designed so that no water nor harmful vapor can penetrate therein, and completely free from the formation of vapor.

Consequently, after a period of time this low pressure maintains the quality of the watch, the organs and the lubricants oxidizing with greater difficulty than for a normal movement not subject to a partial vacuum which may not necessarily be fully waterproof, while a case maintained under a partial vacuum must be perfectly watertight.

In known watches housed in a casing under a reduced pressure, the initial chronometric qualities have not been improved, but they are better maintained over a period of time.

On the other hand, efforts are continually being made to improve the chronometric quality of mechanical watches to render them comparable to electronic watches.

Attempts have been made to improve this quality by an increase in vibrational frequency of the mechanical oscillator (sprung balance). The increase in this frequency poses the problem, in classic movements, of energy accumulation, as a considerably increase in driving power is necessary. In order to be able to attain a sufficient power reserve, watchmakers have tended to decrease the moment of inertia of the balance to such a degree that the chronometric qualities of these movements have been only slightly improved.

It is known that the regulating qualities of a mechanical oscillator spring balance mechanism vary according to its virtual power. There is therefore no need to show that the gain obtained on the latter by present high-frequency calibers is very slight, the improvement on their chronometric performance being due to the diminution of the perturbations to the period of the balance by external shocks.

An object of the invention is to provide a timepiece with a substantial increase in the virtual power of its oscillator and thereby a considerable increase in the chronometric qualities of this watch.

According to the invention, there is provided a timepiece having a timekeeper comprising an oscillator operating in a fluidtight enclosure in which the pressure is below 1 mm. of mercury.

The invention will now be particularly described, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a diagrammatic partial plan view of a frequency regulator used in the timepiece according to the invention,

FIG. 2 is a partial view of a first modification of the device in FIG. 1,

FIG. 3 is a diagrammatic sectional view of a part of the device of FIG. 1,

FIG. 4 is a diagrammatic sectional view of a second modification showing the sealed space, and

FIGS. 5 and 6 are two graphs showing the chronometric qualities as a function of the degree of vacuum.

The device diagrammatically shown in FIG. 1 comprises a classic index assembly 1 mounted on a balance cock 2. This index assembly comprises an index in two parts, part 3 which has a short shank 3*a* and carries the banking pins of the effective length of the balance spring 4 of a sprung-balance oscillator (not shown), and part 5, which forms the shank of the index ending in a fork 6 able to be rotated by the eccentric 7.

The part 3 is the moving organ acting on the oscillator to alter the frequency thereof.

So as to be able to operate part 3 from the outside, two bimetal strips 8 and 9 are provided, and fixed on the balance cock 2, for example. When these bimetal strips are heated they bend in the direction indicated by arrows A and R. Each bimetal strip 8 and 9 can be directly heated, for example, as shown by supplying current to them via the wires 10 and 11, the body of each bimetal strip acting as a heating resistance, either directly by a heating resistance incorporated in the bimetal strip or in contact with it. The circuit return for the two resistances is to ground and is formed by the balance cock itself.

When, for example, the bimetal strip 8 is heated, it bends according to arrow A, comes into contact with moving organ 3 and moves it in the direction of the arrow, thus increasing the frequency of the oscillator. When heated, the bimetal strip 9 moves the organ 3 in the direction of arrow R, which lowers the oscillator frequency.

The wires 11 and 10 feeding the current to the bimetal strips are soldered to two contacts 12 and 13 so mounted as to maintain the seal on the back cover 14 of the case, as shown in FIG 3, these contacts being insulated at the back if this is in metal, by means of glass sleeves 15 and 16 which are welded for example. The fluidtight and insulated assembly can be easily provided by contacts and a back made in a metal which can be welded to glass, as known. In order to alter the adjustment with such a device enclosed inside a hermetrically sealed case, for example to increase the frequency, it is only necessary to pass a current between the contact 12 and the ground constituted by the metal back, thus heating the bimetal strip 8 which pushes the index, the circuit being broken when the desired correction has been made.

In order to slow down the watch, the current is fed to contact 13. It can be seen that this device is particularly simple and enables adjustments to be made very easily, without dismantling the case and without having moving organs through the case.

In the variation shown in FIG. 2, the correction is made by an eccentric 7 provided for this purpose with a maneuvering shank 7*a* on which the bimetal strips (partially shown) respectively act.

In the variation shown diagrammatically in FIG. 4, the oscillator is a sprung-balance type, electronically maintained by the coils 21 and 22 cooperating with a magnetic field produced by two magnets 23 and 24. The length of the balance spring is regulated by an index assembly similar to that previously described and which can be moved by two bimetal strips 25 and 26.

In this variation, only the oscillator and the means of supply and adjustment thereof are contained in a hermetically sealed space, formed by a case 27 and a cover 28. In this enclosed space, a very slight pressure is produced in the order of one-thousandth of a millimeter of mercury. This space is provided with sockets 31–35 provided with insulation between them and the enclosure. Theses sockets form the output from the electrical circuits feeding the coils and the two bimetal strips. The oscillator and means of adjustment and supply thereof form a unit which can be plugged into a case containing the electronic circuit, the source of the current and the hour display device. This case could also have the air removed or, on the contrary, be filled with an inert gas or air at low pressure.

It is evident, without departing from the scope of the invention, that the oscillator could be of another type: for example, a diapason with adjustment carried out by bimetal strips moving a magnetic-regulating organ.

Although the frequency regulation has been described as being carried out by electrical heating of the bimetal strips, it is evident that they could be heated separately by a beam of light concentrated on at least a part of the said bimetal strip, which for this purpose may have a portion coated with a light-absorbing substance, thereby facilitating heating. It is only necessary for this purpose of heating by a light beam, to provide a back cover having a transparent section opposite the bimetal attachments.

The generally rather high frequency of the electronic oscillator is considerably reduced by means of a transistorized electrical frequency divider, preferably in the form of an in-

tegrated circuit. The display can be achieved with a step-by-step motor. Such motors already exist for watches and their current consumption is very low.

It is known, on the other hand, that the quality factor Q varies as the differences in energy losses according to the relation

$$Q=\frac{2\pi E}{\Delta Es+\Delta Ep+\Delta Ea} \quad (4)$$

in which:

E is the oscillator energy,

ΔEs is the energy loss due to internal friction of the balance spring,

ΔEp is the energy loss due to friction of the pivots in the bearings, and

ΔEa is the energy loss due to the friction of the air.

It has been found by experience that Es is negligible in relation to the sum of $\Delta Ep+\Delta Ea$.

The state of present day technology excludes the possibility of a spectacular decrease in the factors Es and Ep.

In a mechanical watch of high frequency, this factor Ea is by far the most important in value. It is therefore, judicious to concentrate on this factor.

In reducing the pressure inside the case, the value of this factor approaches zero and, thereby, the Q-factor considerably increases. This increase in the Q-factor leads to a parallel increase of the virtual power of the oscillator for a given dissipation of energy, ΔP.

The curves reproduced in FIGS. 5 and 6 show the increase of the chronometric qualities of a conventional mechanical watch with a balance spring and escapement working in a vacuum, and in which the entire movement is enclosed in a sealed case with a reduced pressure therein.

Q indicates the quality factor and P the pressure in millimeters of mercury.

The curve of FIG. 5 shows the increase of the Q-factor in relation to the pressure P inside the case of a watch, the frequency of which is 18,000 vibrations per hour, for example. The value of this factor increases from 150 at normal pressure to about 380 at a pressure of 10^{-3} mm. of mercury. Below this pressure the gain of the Q-factor is negligible.

If the same balance is made to oscillate at a higher frequency, 36,000 vibrations per hour for example, the curve shown in FIG. 6 is obtained. The Q-factor then increases from about 275 at atmospheric pressure to about 700 for pressure equal to or lower than 10^{-3} mm. of mercury while maintaining a sufficient power reserve in the watch.

Moreover, such a watch differs from those now known, by the fact that its movement is incapable of working correctly at normal atmospheric pressure. The movement of this watch must be conceived entirely in terms of the extreme vacuum in which its oscillator works.

What is claimed is:

1. In a timepiece having a timekeeper including an oscillator operating in a fluidtight enclosure in which the pressure is less than 1 mm. of mercury, means for dividing the frequency of the oscillator, and display means, an improvement comprising a device for regulating the frequency of the oscillator, said regulating device comprising mobile organ means movably mounted within the enclosure for movement to modify the frequency of the oscillator, and at least one bimetal strip means which can be bent by thermal action to contact and move said mobile organ means, and means outside said enclosure for at least momentarily controlling the temperature of said strip means.

2. A timepiece according to claim 1, comprising two said bimetal strip means, one strip means for moving said mobile organ means to increase said frequency, and the other said strip means for moving said mobile organ means to decrease said frequency.

3. A timepiece according to claim 1, in which said bimetal strip means is electrically heatable and further including electrical conductor means connected between said strip means and the exterior of said enclosure, wherein said means for controlling the temperature of said strip means includes means for flowing a current through said conductor means and strip means.

4. A timepiece according to claim 3, wherein said conductor means includes a terminal, and insulating fluidtight means for mounting said terminal in a wall of said enclosure.

5. A timepiece according to claim 1, further comprising electrical means in said enclosure for maintaining the frequency of said oscillator.

6. A timepiece according to claim 5, wherein said fluidtight enclosure and its contents form a unit which can be plugged into a watch casing.

7. A timepiece according to claim 1, wherein said bimetal strip means is heatable by a light beam emanating externally of said enclosure.

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