

PATENT SPECIFICATION

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(54) IMPROVEMENTS IN OR RELATING TO METHODS AND APPARATUS FOR MEASURING THE ACCURACY OF ELECTRIC TIMEPIECES

(71) We, KABUSHIKI KAISHA SUWA SEIKOSHA, a Japanese company of 3-4, 4-chome, Ginza, Chuo-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to methods and apparatus for measuring the accuracy of electric timepieces and more specifically to methods and apparatus for measuring the accuracy of timepieces of the kind in which a quartz oscillator or like crystal vibrator is used as the time standard.

Timepieces of the kind referred to can be made of very high accuracy because a quartz oscillator or like crystal vibrator is of very high stability of frequency. In such a timepiece, the highly stable oscillations of the quartz oscillator are fed to a series of frequency dividers or counters which produce therefrom accurately timed signals which are suitable for and are used for energising a motor driving the hands or other time indicating means of the timepiece. Such timepieces were at first used for table and similar clocks where high time-keeping accuracy was required. More recently, however, successful miniaturisation of the vibrator or oscillator, and of the associated circuitry, has enabled much smaller time-pieces, notably wrist-watches, to be of this kind and mass production of wrist watches of this kind is now possible. There has arisen a requirement for the accuracy of a timepiece of the kind referred to to be measured quickly and easily. In the case of a wrist watch customary requirements are that the watch shall be waterproof and shock resistant, and tests for these qualities, and for the effects of ambient temperature changes, are commonly required to be made when the watch is enclosed in its case. Customary present day practice in measuring the accuracy of a watch of the kind referred to is to take off part of the electrical

output of the time-standard oscillator to an accurately calibrated electrical counter by means of which the required accuracy-checking measurement is made. To do this an output terminal is provided on the watch case and electrical output from the oscillator is fed to this terminal from which the oscillations to be counted are taken. The provision of such an output terminal for leading electrical oscillations from the quartz oscillator or vibrator inside the watch case to an external measuring apparatus, has, however, obvious serious disadvantages, more especially as regards maintaining a high standard of waterproofing, high mechanical strength and good protection against shock.

It is, of course, well known to check the accuracy of a mechanical watch or clock having an escapement or similar movement which emits a "ticking" sound loud enough to be audible to the human ear, by arranging a microphone to "listen" to the "tick" and providing electrical measuring apparatus to which the electrical output (corresponding to the ticking) from the microphone is fed. In a timepiece of the kind referred to, however, the time standard is a quartz crystal the frequency of oscillation of which is very much higher than that of an escapement and the mechanical movements of which have an amplitude which is very much lower than the amplitude of an escapement so that there is no "ticking" sound. Because of this it has hitherto been assumed that a microphone cannot be used to provide an electrical output to an electrical circuit for checking the time accuracy of a timepiece of the kind referred to, and, for this reason, timepieces of the said kind have been provided with output terminals for taking off electrical output from the quartz oscillator despite the manifest defects of this practice and despite that microphone actuated-time measuring circuits have been known, and used for time checking mechanical, "ticking" timepieces, for more than a decade.

[Price 25p]

Price 75p

The present invention seeks to provide improved methods and means whereby the accuracy of the watch of the kind referred to can be measured, quickly and easily, without taking off any electrical signals whatever to the exterior of the watch case. Thus the need for any output terminal on the watch case is obviated and the case can be sealed waterproof and shock resistant and tests of these qualities and of temperature coefficient, can be carried out without interfering in any way with the sealed case.

As is well known, normal practice as regards the quartz crystal of a quartz crystal time standard oscillator of a watch is to support the crystal by a support wire which is also used as the connecting lead for supplying driving voltage to the crystal electrode system. The crystal vibrates mechanically under piezo-electric action at the natural (driven) frequency of the crystal. It has now been found that a perceptible portion of these mechanical vibrations, though very small in amplitude, travels along the supporting wire to the watch case (from which they are dissipated to constitute part of the total energy loss of the crystal when vibrating), and can be picked up by a microphone in mechanical contact with the outside of the case.

According to this invention a method of measuring the time accuracy of an electric timepiece of the kind having a time standard quartz oscillator or like crystal vibrator which is supported from the case of the timepiece and from which signals for driving the time indicator of said timepiece are derived by frequency division of the time standard oscillations consists in placing in temporary physical contact with the outside of the case a microphone which picks off from the case acoustic vibrations leaked to said case from the mechanical vibrations of said crystal, converting said acoustic vibrations into electrical oscillations and measuring the frequency of said electrical oscillations.

The measurement of the frequency of the electrical oscillations into which the acoustic vibrations of the timepiece case are converted is preferably effected by a frequency measuring device which is fed through an amplifying circuit arrangement which includes at least one crystal filter stage attuned with the natural frequency of the time standard oscillator or vibrator of the timepiece and is fed from a sensitive microphone in contact with the case of the timepiece.

The invention is illustrated in the accompanying drawings, in which:—

Figure 1 is a block diagram representing the timepiece, the timing accuracy of which is to be measured and the remaining apparatus by means of which the measurement is effected, and

Figure 2 is a simplified circuit diagram of a preferred form of circuitry employed

between the microphone 2 and the counter 6 of Figure 1.

Referring to Figure 1, block 1 represents an electric wrist-watch of the kind having, as its time standard, a quartz oscillator or like crystal vibrator from which electrical signals for driving the time indicator of the watch are derived by frequency division, and which is supported, inside the case of the timepiece, by a support wire which is also used as the connecting lead for supplying driving voltage to the crystal electrode system. A highly sensitive microphone 2 is suitably mounted (by means not shown) so as to be in physical contact with the case of the watch. A sensitive microphone, so mounted, will pick up and convert into electrical oscillations, acoustic vibrations (despite their very small amplitude) which are leaked to said case and are caused by the mechanical vibrations of the quartz crystal. The output from the microphone is amplified by a first amplifier 3 followed by a crystal filter 4 which may consist of one or more crystal filter stages tuned to the predetermined time standard frequency of the quartz oscillator or like crystal vibrator in the watch. The filtered output from the filter is further amplified by a second amplifier 5 the output from which is fed to a counter 6.

Figure 2 which, it is thought, will be found almost self-explanatory, shows suitable circuitry for the parts 3 to 5 inclusive of Figure 1. As will be seen the filter 4 comprises two quartz filter stages 41 and 42 with a buffer amplifier 43 between them. The accuracy of measurement attainable with circuitry as shown in Figure 2 has been found in practice to be of the order of 10^{-7} to 10^{-8} , which is adequate for practical purposes.

As will be seen the invention enables the accuracy of a quartz crystal time standard wrist watch to be measured very accurately without leading out any electrical signals from the watch and without interfering with it except by contacting the case of the watch with the microphone.

Therefore the invention lends itself admirably to the accuracy checking of mass-produced quartz crystal watches and all the difficulties and defects involved in taking out electrical signals from the interior of the watch case are avoided.

In the arrangement illustrated in the drawings an electronic counter 6 is used for measuring the frequency. However, if desired, a digital-analogue converter could be employed.

It should be specially noted that, with a method and apparatus in accordance with this invention, the acoustic vibrations leaked to the case of the timepiece and picked up by the microphone are from the time standard quartz oscillator or like crystal vibrator itself. This feature is very important to the obtain-

ing, of high precision in measuring the accuracy of the timepiece and is essential to the obtaining of a desirably high degree of such precision.

5 WHAT WE CLAIM IS:—

1. A method of measuring the time accuracy of an electric timepiece of the kind having a time standard quartz oscillator or like crystal vibrator which is supported from the case of the timepiece and from which signals for driving the time indicator of said timepiece are derived by frequency division of the time standard oscillations, said method consisting in placing in temporary physical contact with the outside of the case a microphone which picks off from the case acoustic vibrations leaked to said case from the mechanical vibrations of said crystal converting said acoustic vibrations into electrical oscillations and measuring the frequency of said electrical oscillations.

2. Apparatus for carrying out a method as

claimed in claim 1 wherein the measurement of the frequency of the electrical oscillatory output of the microphone is effected by a frequency measuring device which is fed from the microphone through an amplifying circuit arrangement which includes at least one crystal filter stage attuned with the natural frequency of the time standard crystal of the timepiece.

3. A method of measuring the time accuracy of electric timepieces of the kind referred to substantially as herein described with reference to the accompanying drawings.

4. Apparatus for carrying out a method as claimed in claim 3 substantially as herein described and illustrated in the accompanying drawings.

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