TIMEKEEPER CORRECTED BY ELECTRIC TIME SIGNALS

Filed Aug. 27, 1963

FIG. 1

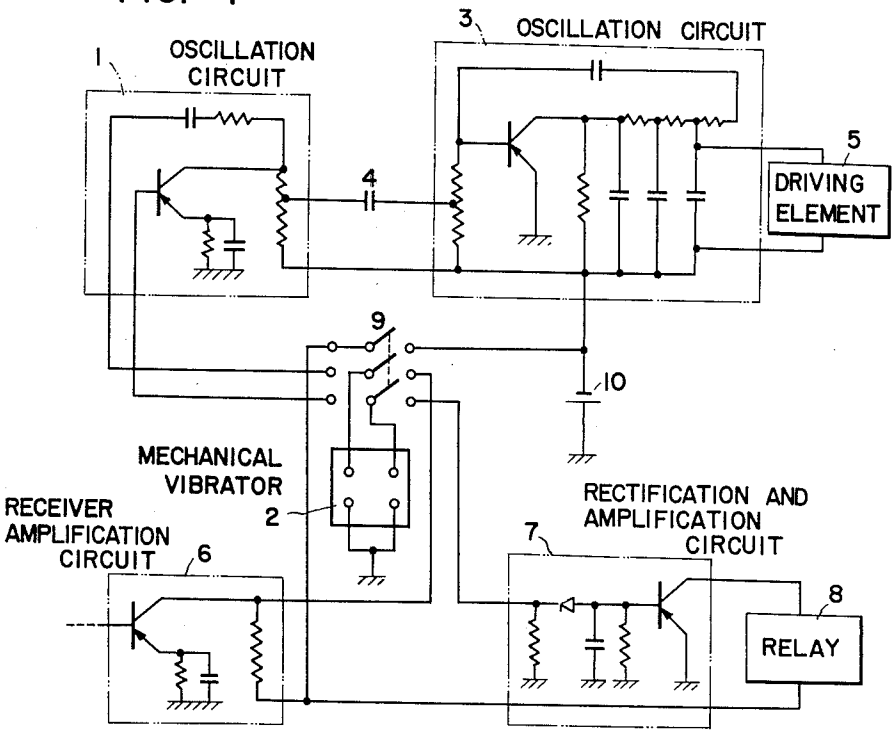


FIG. 2

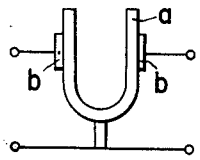


FIG. 3(A)

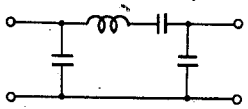


FIG. 3(B)

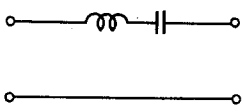


FIG. 4(A)

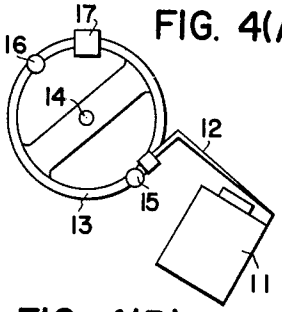


FIG. 4(B)

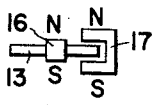


FIG. 5(A)

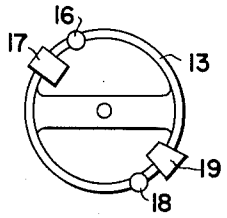
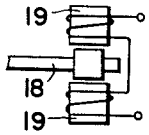


FIG. 5(B)



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3,167,906

TIMEKEEPER CORRECTED BY ELECTRIC TIME SIGNALS

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2 Claims. (Cl. 58—35)

The present invention relates to a timekeeper capable of being corrected in the error of the timekeeping mechanism by electric time signals such as time signals transmitted on short, intermediate, or other electric wave, and more particularly, this invention relates to a new and improved timekeeper having highly advantageous features.

It is an object of the present invention to provide a timekeeper in which any error of the timekeeping mechanism is surely corrected despite of having a relatively simple circuit arrangement, accurate driving of the time-indicating hands, high mechanical strength and durability, particularly against shock, stable operation over a long period, and features contributing to low price.

The foregoing object, as well as other objects and advantages, have been achieved by the present invention, the nature, principle, and details of which will be best understood by reference to the following description of a preferred embodiment of the invention, taken in conjunction with the accompanying drawing, in which the same or equivalent members are designated by the same reference numerals, and in which:

FIGURE 1 is an electrical circuit diagram showing the composition and arrangement of the embodiment;

FIGURE 2 is a schematic elevational view showing one example of the construction of a vibration element for use in the embodiment shown in FIGURE 1;

FIGURES 3(A) and (B) are electrical equivalent circuits of the vibration element shown in FIGURE 2;

FIGURE 4(A) is a schematic plan view showing one embodiment of a driving element for driving the hands of the timekeeper according to the invention;

FIGURE 4(B) is a schematic side view showing the permanent magnets of the driving element shown in FIGURE 4(A);

FIGURE 5(A) is a schematic plan view showing a modification of the embodiment shown in FIGURE 4(A); and

FIGURE 5(B) is a schematic side view of the electromagnet and magnetic piece of the embodiment shown in FIGURE 5(A).

Referring to FIGURE 1, in the circuit of the embodiment shown, there is provided a separately excited oscillation circuit 1 for providing an electrical oscillation of a frequency f_1 and an electromechanical vibrator 2 which serves as the oscillation element for the oscillation circuit 1. The vibrator 2 may be, for example, one which comprises a mechanical vibrating element *a* and transducers *b* to convert electrical oscillation into mechanical vibration, as shown in FIGURE 2. The electromechanical vibrator 2 has an electrical equivalent circuit as indicated in FIGURE 3(A) or (B). There is further provided an RC or LC self-excited oscillation circuit 3 which generates oscillation of a frequency f_2, and which is coupled to the oscillation circuit 1 by an impedance element 4 for coupling which consists of a component such as a capaictor or a transformer. The output side of the circuit 3 is connected to a driving element 5 for driving the hour hand, the minute hand, the second hand, and any other mechanical element as necessary of a timekeeper (not shown). The driving element 5 consists of electromagnetic driving elements such as suitable electromagnets as will be described hereinafter and, in accordance with the output of the oscillation circuit 3, creates mechanical reciprocating motion, which is converted into rotational motion by suitable means to drive the hands of the timekeeper.

The electrical system is further provided with a low-frequency amplification circuit 6 which is that of, for example, a radio receiver, and a rectification and amplification circuit 7 to rectify the output of the low-frequency amplification circuit 6 and to amplify the rectified output. The output of the circuit 7 is supplied to a relay 8 which is thereby excited and activates a device for correcting the indications of the various timekeeper hands. This regulating device may be of known type and may comprise, for example, a plunger activated by the relay 8 and a cam mechanism driven by the plunger.

A ganged changeover switch 9 which is connected as indicated in FIGURE 1, is normally positioned on the lefthand side (as viewed in FIGURE 1), thereby causing the mechanical vibrator 2 to be connected to the oscillation circuit 1, whereby its oscillation frequency is maintained accurately at f_1. During a suitable time period bracketing the time of a time signal, this switch 9 is switched and placed in the righthand position (as viewed in the drawing) to cause the mechanical vibrator 2 to be inserted between the receiver amplification circuit 6 and the rectification and amplification circuit 7. The switch 9 may be operated automatically by suitable means, for example, means comprising a time switch or timer engaged with one of the hands of the timekeeper, an electromagnet, and its circuit which is automatically maintained closed for a suitable time by the time switch or timer, whereby automatic switching operation of the switch 9 is accomplished by the attractive force of the electromagnet. Electric power for the transistors and other components in the circuits 1, 3, 6 and 7 is supplied by a power source 10.

In FIG. 4 is shown one specific embodiment composing the afore-mentioned driving element 5 for driving the hands of the timekeeper, said embodiment comprising an electromagnet 11, and iron piece 12 which is, in normal state, maintained at a position apart from the magnetic pole of said electromagnet 11 by means of a spring (not shown), a balance wheel 13 having a rotary shaft 14, a projection 15 provided at a part of the balance wheel 13, a permanent magnet 16 attached to a part of the balance wheel 13, and another permanent magnet 17 having a fork-shaped section so adapted, as shown in FIG. 4(B), that its poles are disposed on either side of a part of the balance wheel 13, the magnetic poles of said magnet 17 being of the same polarities as those of the permanent magnet 16. The coil of the electromagnet 11 is supplied with a half-wave rectified current of the output power of the oscillator 3 or with a rectangular current or triangular current which is synchronized with the output power of the oscillation circuit 3.

Now, upon application of a rectified current converted from the output current of the oscillation circuit 3 to the electromagnet 11, the iron piece 12 is attracted by the said electromagnet 11 against the spring force, whereby the projection 15 is pushed by the end of the iron piece 12, thus rotating the balance wheel 13 in the clockwise direction. However, when the permanent magnet 16 is made to approach the permanent magnet 17 and the attraction force of the electromagnet 11 decreases, the balance wheel 13 is made to rotate counterclockwise by the repulsion force between the permanent magnets 16 and 17. Accordingly, if the oscillation period of the output current of the oscillation circuit 3 is suitably selected, periodic attraction and retraction of the iron piece 12 can be effectively accomplished by periodic excitation of the electro-

magnet 11, whereby the balance wheel 13 is alternately rotated in the clockwise and counterclockwise directions. Accordingly, a unidirectional torque can be taken out by combination of the balance wheel with a mechanism such as a ratchet wheel, escape wheel or angle piece and the hands of the timekeeper can be driven through a suitable gear train by said unidirectional torque.

As the element 5 for driving hands of the timepiece by means of the output power of the oscillation circuit 3, the element such as illustrated in FIG. 5 may be utilized in the place of the element illustrated in FIG. 4. The element of FIG. 5 comprises a balance wheel 13 having a rotary shaft 14, permanent magnets 16 and 17, a magnetic piece 18 provided on a part of the balance wheel 13, and an electromagnet 19 provided with a core having a fork-shaped section, said members 13, 14, 16 and 17 being the same as those in the element of FIG. 4.

In the embodiment of FIG. 5, when a half-wave rectified current converted from the output power of the oscillation circuit 3 is applied to the coil of the electromagnet 19, the magnetic piece 18 is attracted by said electromagnet, whereby the balance wheel 13 is rotated counterclockwise. Thus, when the permanent magnet 16 approaches the permanent magnet 17 and the attraction force of the electromagnet 19 decreases, the balance wheel 13 is now rotated clockwise by the repulsion force between the permanent magnets 16 and 17. Then, the balance wheel 13 is again rotated counterclockwise in synchronism with the oscillation output of the oscillation circuit 3. The above-mentioned counterclockwise and clockwise rotations of the balance wheel are alternately repeated, whereby the same operation of the time piece as that described in connection with the embodiment of FIG. 4 can be attained.

Referring again to FIGURE 1, the operation of the embodiment of the invention having the abovedescribed construction and arrangement will now be considered hereinbelow. When the changeover switch 9 is in contact with the contacts on the left side (as viewed in FIGURE 1), that is, when the apparatus is in the state wherein time signals are not receivable, the mechanical vibrator 2 is connected to the oscillation circuit 1, operating as the oscillator thereof and causing oscillation at a frequency of f_1. The oscillation output so produced is applied, by way of the coupling element 4, to the CR or LC oscillation circuit 3, whereby the oscillation frequency f_2 of the circuit 3 is locked in the frequency f_1. For this purpose, the difference between f_1 and f_2 is preferably made small and, in some cases, may be zero, so that $f_1=f_2$. The output of the oscillation circuit 3 is applied to the driving element 5, thereby imparting thereto a reciprocating motion in accordance with the oscillation frequency. In the driving element 5, this reciprocating motion is converted by suitable means into rotational motion which is utilized to drive the hands of the timekeeper. In this case, by suitably selecting the aforesaid oscillation frequency f_1 and, at the same time, interposing a mechanism such as a gear train of suitable gear ratios between the aforesaid means for conversion of reciprocating motion into rotational motion and the timekeeper hands, it is possible to drive the hands with substantial accuracy.

Then, at a suitable instant of time prior to receiving a time signal transmitted by an electric wave, the changeover switch 9 is switched to the righthand side (as viewed in FIGURE 1). As a result, the mechanical vibrator 2 is connected between the receiver amplification circuit 6 and the rectification and amplification circuit 7, and, at the same time, the power source 10 is connected to both amplification circuits. Therefore, if the resonance frequency of the mechanical vibrator 2 is selected to coincide with the time signal frequency or to have a narrow band with the time signal frequency as a central frequency, only the time signal which has undergone low-frequency amplification in the receiver amplification circuit 6 is applied, through the vibrator 2, to the amplification circuit 7, where it is rectified and amplified to excite the relay 8.

The relay 8 so excited drives a suitable means such as a plunger, whereby the hands of the timekeeper are corrected to the correct time.

After a suitable time subsequent to this correction operation, the switch 9 is switched back to its normal position, and the vibrator 2 is again connected to the oscillation circuit 1, which is thereby caused to produce an oscillation output of accurate, constant frequency.

During the correction by a time signal, the low-frequency oscillation circuit 1 ceases to oscillate, and the driving of the timekeeper hands is accomplished by the output of the CR or LC oscillation circuit 3. Consequently, during this interval, since the oscillation frequency of the oscillation circuit 3 is subject to slight fluctuation as compared with that of the oscillation circuit 1, the driving of the timekeeper hands may become relatively inaccurate. However, since this interval is very short, and, moreover, since the correction by a time signal is accomplished during this interval, the error arising during this interval is of negligible magnitude.

The foregoing description has concerned the case wherein the same frequency is utilized for both uses of the mechanical vibrator 2, that is, as an oscillation element of the oscillation circuit 1 and as an interstage selecting filter between the amplification circuits 6 and 7. However, in either case, for example, when the vibrator 2 is used as an oscillation element, the spurious frequency of the vibrator may be utilized, and when the vibrator is used as a selecting filter, the fundamental frequency or a harmonic frequency thereof may be utilized.

As will be apparent from the above description, since, in the present invention, a common mechanical vibrator is used doubly by switching as an oscillation element of a separately-excited oscillation circuit for driving the timekeeper hands and as a filter for time signal selection, the circuit arrangement is relatively simple.

Furthermore, in the present invention, the output of an oscillation circuit provided with a mechanical vibrator as an oscillation element is used as above described for driving the timekeeper hands in an accurate manner. Accordingly, the mechanical parts of the apparatus have high mechanical strength compared with conventional apparatus wherein parts such as balances are used. As a result, there is little possibility of damaging the driving mechanism even when the timekeeper hands are subjected to impact stress at the time of correction by a time signal, wherefore the timekeeper according to this invention is highly durable and stable over a considerable length of time.

Furthermore, even when a vibrator of relatively inferior performance is used, errors are readily eliminated by periodic correction. Accordingly, the timekeeper of this invention can be manufactured easily and cheaply.

It should be understood, of course, that the foregoing disclosure relates to only preferred embodiments of the invention and that it is intended to cover all changes and modifications of the examples of the invention herein chosen for the purposes of the disclosure, which do not constitute departures from the spirit and scope of the invention as set forth in the appended claims.

What we claim is:

1. A timekeeping device corrected by an electric time signal comprising, a first oscillatory circuit, a second oscillatory circuit frequency locked with said first oscillatory circuit to supply driving power for driving said device, said second oscillatory circuit comprising a self-exciting oscillatory circuit, a time signal receiving circuit, a resonator normally connected to sad first oscillatory circuit to control the frequency thereof, means to switch over said resonator to connect it to function as a signal selecting wave filter in said time signal receiving circuit during a selected interval of time just before and after arrival of said time signal, a driving element to receive the output of the said self-excited second oscillatory circuit during all the intervals when said resonator functions to control

the frequency of said first oscillatory circuit and as said filter, an automatic switching means to actuate said switch-over means to operably connect said resonator to said first oscillatory circuit and to operably connect said resonator during a few seconds just before and after said time signal is received in an operative condition to function as said filter of the time signal receiving circuit, whereby the indications of said devices are corrected in response to and in accordance with the time signals selected and received.

2. A timekeeping device corrected by an electric time signal comprising, a first oscillatory circuit, a second oscillatory circuit frequency locked with said oscillatory circuit to supply driving power for driving said device, said second oscillatory circuit comprising a self-exciting oscillatory circuit, a time signal receiving circuit, an electromechanical resonator normally connected to said first oscillatory circuit to control the frequency thereof, means to switch over said resonator to operably connect it to function as a signal-selecting wave filter of said time signal receiving circuit during a selected interval of time just before and after arrival of said time signal, a driving element to receive the output of the said self-excited second oscillatory circuit during all the intervals when said electromechanical resonator functions to control the frequency of said first oscillatory circuit and as said filter, automatic switching means to actuate said switch over means to operably connect said electromechanical resonator to said first oscillatory circuit and to operably connect said electromechanical resonator to said first oscillatory circuit and to operably connect said electromechanical resonator during a few seconds just before and after said time signal is received in an operative condition to function as said filter of the time signal receiving circuit, whereby the indications of said device are corrected in response to and in accordance with the time signals selected and received.

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